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This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE EAST PROVIDENCE WATER COMPANY.

BY ALBERT C. DICKERMAN.*

[*Read September 17, 1926.*]

EDITOR'S NOTE: Since this paper was presented the property of the water company has been purchased by the town of East Providence.

The East Providence Water Company was chartered in 1895 by the Rhode Island Legislature and purchased the property and rights of the East Providence Fire District which was incorporated in 1893 to supply a territory defined by the Legislature as "Being all of the Town of East Providence except that supplied by the Watchemocket Fire District" which was incorporated and started business about 1878, its territory being about a mile square in the older and more thickly settled portion of the town of East Providence, bounded roughly by Watchemoket Square, Red Bridge and Broadway.

The population of the town of East Providence, according to the census of 1925, was 25 700. The East Providence Water Company had on December 31, 1925, 3 100 customers, representing a population of approximately 12 000. The territory supplied by the East Providence Water Company consists of the scattered centers of population such as Riverside, Kents Heights, East Providence Center, Rumford, and Phillipsdale, and required unusually long lines of pipe to supply it.

The water company obtained its water at Hunts Mills from the Ten Mile River, a stream rising in Massachusetts and draining an area of approximately 53 sq. miles above the pumping station. The company owns the dam and flowage rights of Old Central Pond, located about a mile upstream from the pumping station and having an estimated storage capacity of between 40 000 000 and 60 000 000 gal.

Studies made of the run-off of the Ten Mile River, following the system used by the Metropolitan District Commission for the Wachusett watershed, as shown in its second annual report, indicate a daily run-off for the driest month of the average year of 15 m.g.d. and for the wettest month of the average year of 147 m.g.d., while for the driest year, the driest month would be 10 m.g.d. and the wettest month would be 102 m.g.d. The gaging records made at Hunts Mills during the years 1922 to 1925 inclusive showed

*Formerly Superintendent, East Providence Water Co.

an actual run-off, for the driest month, of 13.5 m.g.d. and for the wettest month of 183 m.g.d.

From these figures it is apparent that the stream will carry sufficient water to take care of a population several times greater than the present one before additional storage need be thought of.

The main filter plant and pumping station, as well as the office of the company are located at Hunts Mills in East Providence upon the Ten Mile River, a particularly advantageous and attractive spot. Here there is a fall of approximately twenty-two feet, which was taken advantage of to provide gravity flow to the filters. It also enabled the company to generate a part of the power for pumping.

FIG. 1. — PUMPING STATION AT HUNTS MILLS.

The pumping station built in 1893 is an attractive masonry building which originally housed the steam-driven pump, boiler, and water wheels as well as a Knowles Duplex power pump that was driven from these water wheels. (Fig. 1.) A stone addition was built to the pump house in 1910 for the installation of needed motor-driven pumps. Originally the water was pumped directly from the river, but as increasing population and manufacturing above the Hunts Mills made it desirable to treat the water, the filtration plant was built in 1899 to house four 0.5-m.g.d. New York Continental Jewel Filters, one of which was installed at that time. The filter house was built entirely of wood in mill type construction and was placed upon concrete walls which formed a clear well approximately 10 ft. deep. As increased consumption required additional filters they were installed. In 1914 more filter capacity was required, and an addition to the filter house was built to house four 15-ft. filters, two of which were installed at that time, bringing the total filter capacity up to 3 m.g.d.

In 1921 excessive use of wash water due to algæ growths in the river made it imperative that something be done to increase the capacity of the

plant, and it was decided to add a coagulating basin which was built of concrete, 75 ft. long, 45 ft. wide, and 16 ft. deep, containing approximately 400 000 gal. of water. This coagulating basin, together with more careful operation of filters, reduced the use of wash water to an average of 3 to 5 per cent. of the water filtered.

Sulfate of alumina is used as a coagulant and soda ash is added as the alkalinity of the raw water requires. These chemicals are fed by means of Booth dry feeders. The filters are never allowed to deliver water with a color of more than 15 p.p.m.

All high-pressure water is sterilized with chlorine fed by means of Wallace and Tiernan chlorinators. It may be said here that there is no record of epidemics or illness attributed to this water supply.

The author has made a careful study of the several problems involved in this property, including the potential water power due to the fall at the station. As a result of these studies, it was decided to install a new 16-in. force main from the station to the junction of Pawtucket and Taunton avenues, 4 000 ft. away, to make provision for two 3-m.g.d. pumps for use in case of serious fire, to replace the old water wheels and power pump with a new wheel and generator, and to remodel the station in general. So in 1924 a 225-h.p. vertical Leffel wheel direct connected to a 144-k.w. General Electric generator was installed. The old switchboards were removed and a new board was provided which permitted greatly simplified electrical wiring in the station. The new board was so arranged that the new generator would deliver as much power as the stream would develop, the remaining power required being taken from the Narragansett Electric Lighting Company's 2 300-volt line.

In order to use all the power available from the stream as continuously as possible, a 600-g.p.m. Dean Hill pump was installed. This size was chosen to assure continuous operation of the pump. Should the capacity of the pump not meet the demand on the high-pressure system, one of the larger pumps would be started and run until the demand fell off to the capacity of the smaller pump, or until the standpipe was brought back to normal level. The improvement in head conditions, due to the new 16-in. main and to the pumping of a large portion of water at a lower rate, also the high efficiency of the new small pump, reduced the current required for pumping from 2 k.w. per thousand gallons to about 1.65 k.w. It also resulted in better operating conditions in the filter house, by reducing the peak loads on the filters.

The installation of the hydro-electric unit not only proved worth while from the saving in power purchased, but what is more important, it also provides a stand-by service available in an emergency when the central-station connections may have been severed by storm or other accident. The water wheel and generator will, therefore, drive at least one pump during such emergency, even though it is necessary to draw from Old Central Pond, water sufficient to operate the wheel. This feature alone is

desirable, as it insures more dependable fire protection for the town of East Providence.

The pumping equipment now consists of the following units:

One 1 000-g.p.m. four-stage DeLaval centrifugal pump connected to a 200-h.p. motor, installed in 1910.

One 1 200-g.p.m. three-stage DeLaval pump connected to a 200-h.p. motor, installed in 1916.

One 600-g.p.m. Dean Hill three-stage centrifugal pump connected to a 75-h.p. motor, installed in 1925.

One 1 200-g.p.m. DeLaval single-stage centrifugal pump driven by a 50-h.p. motor, for the low-pressure service installed in 1911.

The two DeLaval pumps were purchased to operate at the rated capacities against a head of 420 ft. The 600-g.p.m. pump was purchased to operate against a head of 327 ft. The 1 200-g.p.m. single-stage centrifugal pump operates against a normal head of approximately 100 ft. and is used to deliver water to the Sayles Finishing Plants' property at Phillipsdale, approximately two miles distant. This pump replaced a belt-driven pump installed in 1907 at which time the necessary 12-in. line was run from the pumping station to the storage basins at Phillipsdale.

Electric current is bought or generated at 2 300 volts, three-phase, 60 cycles. This voltage is used for all main pump motors, but is stepped down to 550 volts for small house motors and for the wash-water pump; smaller transformers deliver 110-volt current for lighting.

The East Providence Fire District built on the highest land in the town a steel cylindrical standpipe which maintained water pressure on the system when the pumps were not operating. This tank collapsed in 1894, probably as a result of ice forming in it, and a new standpipe was built by the Riter-Connolley Co. of Pittsburg in 1902. (Fig. 2.) This standpipe or elevated tank was built entirely of steel, the tank being 50 ft. in diameter and 70 ft. high and supported 135 ft. above the foundations, on steel columns and was reputed to be the largest tank in the country at the time it was constructed. It is a landmark which can be seen from a large portion of the State.

The original system of piping was extended both in cast-iron pipe and in wrought-iron pipe so that at the end of 1924 there were 53 miles of pipe supplying the customers on the high-pressure system. About 38 miles of this system consist of cast-iron pipe, mostly 6, 8, 10, 12, and 16 in. in diameter, and about 15 miles of galvanized wrought-iron pipe, mostly 2 in. in size. During recent years of operation it has been the practice of the company to use cement-lined galvanized wrought-iron pipe for services and for temporary mains.

Much of the main lines of the distribution system are rapidly being covered with modern types of roads, mostly of concrete such as is now being built by the State Board of Public Roads. It is the policy of the company to make all necessary improvements previous to the laying of the concrete

roads, such as relocating, where necessary, hydrants, cutting in valves to control the hydrants, so as to reduce the necessity of shutting down any portion of the system to make repairs to hydrants after they had been broken by automobiles. Frequently, it was found wise to start branch mains of 6-in. pipe for streets which are platted along the state highways. In such cases, we carried the branch main to the street line and installed there a gate-valve in readiness to make extensions. The company, also, preceding the

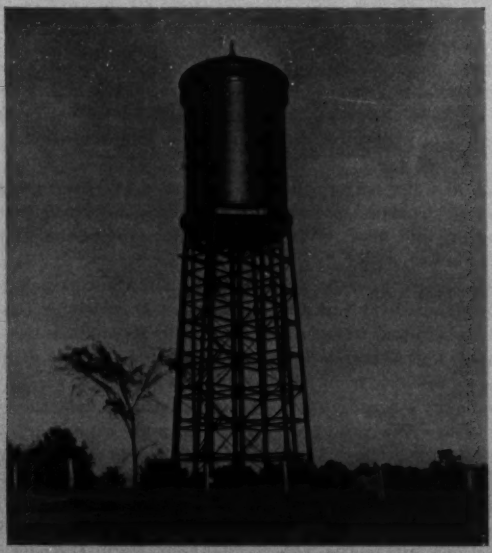

FIG. 2. — 1 000 000-GAL. STANDPIPE.

construction of these permanent roads, cut in additional valves in the mains wherever necessary to make the system more flexible in case of breaks and to reduce the interruptions of continuous service.

There are now 184 hydrants in the system. These hydrants were installed at the company's expense on the order of the town council at locations determined by them. All new hydrants were installed with control valves, and control valves were cut in on old hydrant branches as opportunity arose, particularly on those hydrants located on main thoroughfares. The company furnishes and installs all underground pipe services. The company maintains two 8-in. emergency connections with the piping system of the Watchemoket Fire District at Six Corners, which have proved important to that district in maintaining its service.

The maximum rates of water demand in the high-pressure system that have been reached so far are as follows:

Maximum day	August 23, 1918	2.16 m.g.d.
Maximum week	February 17 to 23, 1923	1.68 m.g.d.
Maximum month	February, 1923	1.66 m.g.d.
Maximum year	1923	1.33 m.g.d.

All water pumped to both high- and low-pressure systems is measured by Venturi meters at the pumping station. About 92 per cent. of the water takers are metered, and it is the intent of the company to approach 100 per cent. meterage as rapidly as expedient. No more applications for fixture rates are accepted. About 75 per cent. of the high-pressure water registered by the Venturi meters is accounted for by customers' meters. This figure was only obtained by great care in maintaining the customers' meters.

In 1925, 98.7 per cent. of the customers used 34.7 per cent. of the high-pressure water registered on customers' meters, which figures about 95 gal. per day per customer. Nine of the large customers accounted for 55 per cent. of the water sold.

Two trucks are in nearly constant use, a 1-ton Ford truck used by the construction department and a ½-ton Yellow Cab truck by the meter department. In addition to these, the foreman is provided with a Ford runabout to enable him to keep in touch with work going on and to give prompt attention to complaints from customers and to emergency calls.

The company's accounts are kept in accordance with the system recommended by the Association of Public Utilities Commission. While this involves extra work, we feel it worth while as it gives a better knowledge of our operations.

Customers are billed annually in most cases, but in order to relieve the office of the work of getting out all bills at one time, we divided the town into four sections, one section being billed February 1, the next on May 1, and the others on August 1 and November 1. All meters are read quarterly to correspond with the billing dates.

The operating personnel of the company consists of the superintendent, chief engineer and three assistants or watch engineers, operating the pumping station and filter plant, a foreman, in charge of the meter department of four men who set and repair meters, and of the construction department of from four to eight men, who install services, extensions and hydrants, and make repairs and replacements of the pipe system.

Two clerks and a bookkeeper take care of the office records and billings, deal with customers, and receive applications and payment of bills.

It would not be proper to close this description of the East Providence Water Company's plant, without calling attention to the fact that this company was the pioneer in the use of rapid sand filtration for public water supply in New England.

With this in mind, Mr. Stephen DeM. Gage, Sanitary Engineer for the State Board of Health of Rhode Island, has kindly furnished the author with the following historical summary.

The original installation of a filter at Hunts Mills was made at the instigation of the State Board of Health and as a result of preliminary studies and surveys which that board had made of the health conditions in the town and of the quality of the raw water from the Ten Mile River, from which the water supply was being obtained at that time. This is covered in the 1898 report of the Rhode Island State Board of Health, pages 147–152 inclusive. At the time this report was made the city of Providence was also considering filtration of the Pawtuxet River water and there was considerable agitation both in Providence and East Providence against the use of alum in filtration. The report of the State Board of Health to Providence on filtration at that time contains a direct statement that the use of alum would not be injurious to health.

In 1899 Dr. Gardner T. Swartz, Secretary of the State Board of Health, made continuous examination of the East Providence water before and after filtration for a number of months. The results of this study were included in a paper which Dr. Swartz read before the American Public Health Association about November 1, 1899. This paper was published in full with the results of chemical and bacteriological analysis in the 1899 report of the State Board of Health, pages 162–175 inclusive. In that same report the improvement of the East Providence Water Company supply is also discussed on page 4 and on pages 143–144.

If the memory of the writer is correct the East Providence Water Company filters were the first mechanical filters installed for domestic water supply in New England, and the results of Dr. Swartz' study were pioneer results to show that this method of purification could properly be used for the soft waters of New England.

Dr. Swartz had a very high standing among the medical and public health professions and his very positive statements that mechanical filters were suitable for our eastern waters and that alum would not come through these filters in sufficient amounts to have any detrimental effect on the public health were of great influence in getting municipalities and water companies to use this type of filtration. The writer feels in connection with the publication of this paper that these facts should be brought out and due credit given to Dr. Swartz for his pioneer work.

THE EAST PROVIDENCE WATER COMPANY RATE CASE.

BY ALBERT C. DICKERMAN.*

[*Read March 13, 1929.*]

The East Providence Water Company's determined effort for four years to obtain an income sufficient to maintain its system at a proper standard and to pay a reasonable return on its investment, has come to an end by the purchase of the property by the town. The story leading up to this ending of the company's troubles is interesting and perhaps instructive to owners of other privately owned utilities that may be operating under rates which are inadequate. A few words about the early days are needed to develop a background.

The property was first developed by a fire district in 1892–1893 at a cost of a little over $200 000. A $200 000 bond issue was authorized by the Legislature for this purpose. The charter also provided that the fire district could raise additional money by taxing property in the district up to 3 mills on each dollar valuation. Rates were adopted which were identical to those in effect in Pawtucket and in Providence. By the end of 1895 there were 334 customers, 129 being metered, and 63 public fire hydrants.

These customers did not apparently produce revenue enough to cover the district's requirements for money, and taxation was resorted to. This was not popular, some of the property owners refusing to pay the assessment. When, therefore, overtures were made by the water company incorporated in 1895, to purchase the property, the harrassed district saw a way to end its troubles, and a vote to sell was passed at a fire district meeting.

The water company's charter provided that the company could purchase the water system of any fire district in the town provided that within the limits of any fire district which might convey its property to this corporation, such rates should never exceed the rates fixed in such district at the time of the passage of the act.

The company also agreed with the fire district in a supplementary agreement, that it would at any time and from time to time extend its water pipes so as to furnish water to new customers when requested to do so, whenever and as soon as an annual income equal to 10 per cent. of the cost of making such extension should be guaranteed to the satisfaction of the company.

An effort was made by the water company to purchase the other fire district of the town known as the Watchemoket Fire District. During the town meeting at which the question of sale was considered, the water company was criticized for its method of conducting its affairs and for the poor

*Formerly Superintendent, East Providence Water Co.

quality of the water. The move to purchase the water company was defeated.

About 1900, Mr. Frank A. Sayles, owner of a bleachery, now known as the Glenlyon Print Works of the Sayles Finishing Plants, Inc., located at Phillipsdale near Omega Pond, at the mouth of Ten Mile River, purchased the stock of the water company. Mr. Sayles had previously purchased Omega Pond with the dam, flowage rights and a large proportion of the land bordering the pond. The latter purchase made Mr. Sayles the lowest riparian owner upon Ten Mile River.

In 1907, the water company laid a 12-in. main from its plant at Hunts Mills to Mr. Sayles' bleachery, installing special pumps and additional filters at Hunts Mills. This water was delivered at a considerably lower pressure than that supplied to the fire district and supplemented the 1 m.g.d. filter plant owned and operated by the bleachery near Omega Pond.

About 1916 Mr. Sayles transferred the property and water rights in and about Omega Pond to the water company except one parcel originally bought by the bleachery and used by it for a pump house in connection with its own filter plant. The property transferred was of no immediate value to the water company except to reduce the possibility of claims for damages for diversion of water at Hunts Mills.

After the death of Mr. Sayles in 1919, those in charge of his estate, began immediately to study the finances of the water company looking for an explanation for the large deficit which had become a formidable figure. A study of the records of the company showed clearly that the rates had never produced an income sufficient to cover operating expenses, depreciation, bond interest and extensions and improvements to the plant. From time to time, additional stock had been issued to produce capital for extensions and improvements, but no dividends were paid on the stock.

The Sayles estate decided that it was advisable to transfer to the Sayles Finishing Plants, the property and water rights in and around Omega Pond, also other land near the pumping station at Hunts Mills. In order to have unprejudiced advice in arriving at the value of the property to be transferred, Mr. Charles T. Main of Boston was asked to make an appraisal of this property in 1921. The bleachery paid to the water company the amount found by Mr. Main, as the fair value of the property and rights. The proceeds of the sale were used to retire some of the water company's obligations. The purpose of this transfer was to divorce from the company all property which was not used or useful in the operations of the company without impairing its water rights.

In 1923, Mr. Leonard Metcalf, of Metcalf & Eddy of Boston, was asked to make a valuation and report upon the property of the company. Mr. Metcalf reported January 31, 1924, that the fair value of the property of the water company was at least $900 000 and that the criteria of value exclusive of working capital as of December 31, 1923 were as follows:

1. Depreciated reproduction cost at fair prices	$1 176 000
2. Depreciated reproduction cost at present prices	1 465 000
3. Depreciated reproduction cost at pre-war prices	692 000
4. Original cost not available	
5. Book cost	714 000
Estimated value	900 000

The rate should be on a basis to yield a fair return on $975 000, including $75 000 for betterments which should be made. In 1922, the gross revenue was $85 684, whereas the net revenue before any payment for bond interest showed a deficit of $10 829. With the increase in rates to the bleachery, the gross annual revenue increased to $102 000 for the year 1923, but the net revenue was only $21 677 which was but 2.4 per cent. upon a fair value of $900 000. Obviously, the water company must increase its rates or go into bankruptcy.

A summary of revenue and operating expenses for the 10-year period just previous, taken from Metcalf's report is shown in Table 1 together with averages for each 5-year period and the 10-year period, also preliminary figures for 1923.

The rates for low-pressure water delivered to the Glenlyon Print Works, which has taken very large quantities of water, were in general conformity with the published schedule taking into consideration the difference in pressure, but on May 1, 1922 the rate was increased to 10 cents per 1 000 gal., the same rate as on the high-pressure system, in spite of the fact that water was supplied at nearly one-fourth of the high-service pressure.

Mr. Metcalf found that the equitable gross annual revenue from all sources should be $150 000 on the basis of a fair property value of $975 000 including allowance of $75 000 for betterments. This was an increase in gross revenue of about 45 per cent. over the gross annual revenue for the year 1923. After analyzing the cost of furnishing the public fire protection, the cost of furnishing domestic and industrial service, and the cost of the low-pressure service he found the revenue from each class of service should be, if made equitably:

Fire service	$44 000
Domestic and industrial	72 000
Low-pressure service	34 000
	$150 000

The charge of $44 000 he showed was in fair accord with normal practice as shown in a paper upon "Some Fundamental Considerations in the Determination of a Reasonable Return for Public Fire Hydrant Service" by Metcalf, Kuichling and Hawley, published in the proceedings of the American Water Works Association in 1911, page 55. Mr. Metcalf stated that there should be kept in mind:

1. That post-war costs had increased somewhat over 100 per cent. of pre-war costs.

TABLE 1. — SUMMARY OF REVENUE AND OPERATING EXPENSE.

Year ending Dec. 31.	1913.	1914.	1915.	1916.	1917.	Average 5-yr. Period.
Gross Annual Revenue	41 481	42 367	49 548	51 632	51 517	47 305
Operating Expenses*	32 114	32 562	38 312	34 828	40 378	35 640
Operating Revenue	9 356	9 805	11 236	16 804	11 139	11 665
Deduction for Depreciation	10 747	10 892	11 195	11 640	12 075	11 310
Net Divisible Return	−1 380	−1 087	41	5 164	− 936	355

Year ending Dec. 31.	1918.	1919.	1920.	1921.	1922.	Average 5-yr. Period.	Average 10-yr. Period.
Gross Annual Revenue	59 688	78 643	60 486	60 357	85 684†	68 967	58 138
Operating Expenses	66 388	58 994	54 337	55 026	77 268	62 403	49 020
Operating Revenue	−6 720	19 649	6 149	5 331	8 416	6 564	9 116
Deduction for Depreciation	12 282	14 354	20 532	20 532	19 245	17 795	14 334
Net Divisible Return*	−19 002	5 295	−14 231	−15 201	−10 829	−10 795	−5 216

1923. Subject to Revision.

Gross Annual Revenue	102 053	
Operating Expenses*	61 376	(Excluded large part of insurance.)
Operating Revenue†	40 677	
Deduction for Depreciation	19 000	(Estimated.)
Net Divisible Return	21 677	

The net revenue ($21 677) for the year 1923 was but 2.4 per cent. upon the fair value ($900 000) of the property; and 3.1 per cent. upon its cost upon pre-war price bases.

*Including taxes but excluding depreciation.
†Excluding $6 793 received for sale of property.

2. The scattered character of the community served by this company.
3. The effect of a relatively large summer colony at the extremity of the pipe system.

He also pointed out the inadequate number of hydrants in the system, there being 166 equivalent to 4.7 per mile, where good practice would dictate 2½ to 3 times as many.

In further discussion of the division of the cost of service between the different classes of service, Mr. Metcalf stated "it would appear reasonable to ask the public to bear at least one-half of the burden of the cost of the public fire-protection service, which would amount to $22 000 per annum." This would require that the other half of the cost of public fire protection be carried by the domestic and industrial customers and the low-pressure service, which if applied solely to the former would increase the amount received from that class of service from $72 000 per year to $94 000 as compared with $47 000 received in 1923. On the other hand if $7 000 of this unplaced fire-service charge should be added to the cost of the low-pressure service, increasing it from $34 000 to $41 000 and the remaining $15 000 charged to the domestic and industrial service, the total cost of the latter would be $87 000 or 85 per cent. in excess of the 1923 receipts for it.

"As a matter of expediency," Mr. Metcalf said, "it would probably be wise not to attempt to increase the rates by so substantial an amount at the present time. *An increase in the industrial and domestic service (high service) rates of 50 per cent. would clearly be conservative.* This it is assumed would yield the following approximate gross annual revenue."

1. Fire-protection service (cost $44 000)		$22 000
2. Low-pressure service		41 000
3. Industrial and domestic (high-pressure service)		70 000
		$133 000
4. Gross revenue from other sources		2 000
5. Saving from power plant (new hydro-electric plant)		5 000
		$140 000
6. Operation, maintenance and general expense	$54 000	
7. Taxes	14 000	
8. Depreciation	19 000	
		87 000
Net return		$53 000

The net return, on this basis, would be equivalent to 5.5 per cent. on a fair value of $975 000. This rate of return would not be sufficient to attract new capital but Mr. Metcalf stated that "*the economic solution of this problem from the point of view of citizens of East Providence, clearly lies in the consolidation of the water service of the Watchemoket Fire District with that of the remainder of the town, the district served by the East Providence Water Company because in this way, and in this way only, can the cost of collection,*

transporting, pumping and distributing the needed supply be reduced to the minimum."

While Mr. Metcalf was preparing his report the author prepared a new set of rules, regulations and rates, which were filed with the Rhode Island Public Utilities Commission, December 31, 1923 and became effective January 30, 1924 and known as Rhode Island Public Utility Commission No. 4. These rules and regulations were similar to the old ones except that they were assembled in a more orderly manner, vague points made clear and concise, and a few additions were made, such as the following: The length and cost of services to be put in at the company's expense was limited to 20 ft. and a cost of $1.25 per ft.; the fee for setting meters and turning off and on of water was increased from $1.50 to $2.00; a fee of $1.00 per year was added for setting and removing meters in summer cottages or turning the water on and off for the season, if done on a specified day. Another rule was added permitting the collection of the minimum charge for each house where more than one house was being supplied from one service and further requiring that all new houses should have their own service.

The rates for meters and fixtures were left exactly the same as before. No attempt was made to change the arrangements under which extensions would be put in, although the old method of a guarantee of an income of 10 per cent. for cast-iron pipe was burdensome to the company, and the practice of making the original taker pay for the smaller wrought-iron extension, without being able to spread the cost over other property benefited by the extension or to later new customers, was far from satisfactory to that class of customers. It was intended to cover these points later when the company applied for an increase in rates.

After considering Mr. Metcalf's report the Sayles Estate decided to take the case to the Public Utilities Commission and asked Mr. Metcalf to assist the Estate attorneys, Messrs. Edwards and Angell. The valuation for rate purposes was left at $990 000 as these improvements and betterments advised by Mr. Metcalf were being made, and the gross revenue to be asked for was set at $137 000 which would leave a net return of about 5 per cent. on $990 000.

After much discussion it was decided that it would be better to ask for an increase of 50 per cent. on the old meter-rate schedule as this would more easily be understood by the water takers than the more equitable and scientific schedule prepared along the lines recommended by this Association.

The faucet rates were increased from $5.00 to $10.00 for one family and one faucet, and other combinations were increased in lesser extent. The public fire-protection charge asked for consisted of a stand-by or readiness-to-serve charge of $15 000 per year plus a hydrant charge of $40 per year for each hydrant in use or installed in the future. This, it was estimated, should produce the $22 000 income which Mr. Metcalf concluded was the least amount the company should receive for this service. In this schedule a charge was made for the first time for private fire protection. For the

unmetered connection the charge was based on the size of connection or on the number of outlets, with certain qualifications. In the case of plants which had private hydrants or sprinklers, but connected to a metered service a minimum charge was asked for, varying with the size of meter from $90 to $540 per year, but of course entitling the taker to a corresponding amount of water.

In the new rules and regulations filed, an attempt was made to establish a fair basis for providing extensions under the several conditions generally encountered. Permanent pipe would be laid upon receiving a guarantee of an annual income of 15 per cent. of the cost of the installation. Temporary pipe would be laid when the cost was prepaid, and the company would undertake to collect from other takers their share, and refund it to the original depositor. The new rules and rates were to be known as R.I.P.U.C. No. 5. For original rates see the Appendix to this paper.

The new rules and rates were filed with the Utilities Commission on November 28, 1924, together with a letter discussing the need of relief. At the same time a letter was written to the town council of East Providence, calling attention to the necessity of relief and pointing out the injustice to the company of existing fire-protection charges and showing by direct comparison the differences in the old and new schedules, and enclosing a copy of the letter sent to the Utilities Commission. A similar letter was sent to the East Providence Fire District.

On December 15, 1924 the Utilities Commission held a hearing. The town argued that the Commission had no jurisdiction in this case, as a change in the charter was asked for, and on January 19, 1925 the Commission dismissed the company's request in its order No. 875.

In order to clear this point up our attorneys petitioned the Supreme Court of Rhode Island asking for a writ of mandamus to compel the Commission to take jurisdiction of this proposed change in rates. The writ of mandamus was granted in an opinion by the Supreme Court on April 6, 1925 and directed the Commission to take jurisdiction of the matter. The Court held that the State of Rhode Island had delegated to the Public Utilities Commission, its reserved power to alter rates charged by a public utility and that the rates of the East Providence Water Company could be changed by the Commission notwithstanding the provision of the company's charter above referred to. The Commission entered an order on May 1, 1925 rescinding its former order of January 19, 1925 and gave notice of hearings to begin May 21, 1925. Additional hearings were held on May 22, 26, 28 and 29, 1925.

At these hearings, Mr. Metcalf was the principal witness and submitted his evidence of value, and his conclusions as to fair value for rate purposes, its allocation between fire, high- and low-pressure services, together with other evidence of the inadequate income. At the suggestion of the chairman the rates for public fire protection were revised so that the service charge of $15 000 would cover the two fire connections to the system of the

Watchemoket Fire District. A charge for this connection was not included in the schedule as presented, as the company expected this would be determined by negotiations with the district at a later date. Other witnesses for the company furnished information on book figures of cost of plant, adequacy of fire protection and upon character and quality of the service. At the hearings the town was represented only by its solicitor, and presented no evidence to disprove Mr. Metcalf's testimony as to valuation and depreciation or in criticism of his estimates or of his other testimony.

The chairman of the Commission very ably cross-examined the witnesses and showed a clear insight and understanding of the company's problems.

The Utilities Commission on April 28, 1926 ordered, adjudged and decreed as follows:

(1) That the company had sustained the burden of proof as to the necessity of the increased rates contained in schedule No. 5.

(2) That the schedule of rates and charges was just and reasonable and would not yield more than sufficient revenue to provide for the necessary operating expenses, taxes and depreciation and a reasonable return on the fair present value of the property.

(3) That the rules and regulations in said schedule were just and reasonable.

(4) That the company be granted permission to amend the rate for public fire protection so as to include the stand-by service to the Watchemoket Fire District.

(5) That the rates, rules and regulations as amended be permitted to become operative on and after May 1, 1926.

After the Commission's ruling, a special town meeting was called on June 9, 1926 at which time a vote appropriating $25 000 was passed and a committee appointed to protect the town's interests. On May 5, 1926, the town council instructed the town solicitor to file an appeal with the Supreme Court of Rhode Island. The appeal was argued before the Rhode Island Supreme Court November 29, 1926, the water company being represented by Messrs. Edwards and Angell and the town by Mr. Herbert A. Rice.

Mr. Rice attacked the legality of the new rates, first on the score that the water company was not a public utility in its entirety, because of its ownership by the Sayles Estate, which owned Glenlyon Print Works, the largest taker of water from the company and also because the print works was taking from the low-pressure system about 60 per cent. of the total water pumped, in addition to the amount it took from the high-pressure system. He gave figures of water consumed by the print works including the large amount of water taken by it from Omega Pond to emphasize his claim that the public water supply and fire protection were only incidental to the water company's business.

Mr. Rice also argued, that the water company did not sustain the burden of proof as to its necessity for the increased rates. One of his arguments under this heading was that the company was trying to recoup past

losses by an increase in rates, that the company had crippled its business as a public utility by selling its holdings in and around Omega Pond at the mouth of the Ten Mile River, thereby losing its rights of diversion of water. This argument was strongly emphasized although the company at no time had owned more than a small percentage of the riparian rights on this stream, between the Hunts Mills Pumping Station and the mouth of the river. As a matter of fact, it had not released any rights against lower owners.

It was stated, furthermore, that the rates and charges fixed in the order were unlawful and unreasonable. In this argument Mr. Rice claimed that Mr. Metcalf's deductions as to income for public fire service were erroneous because he reduced the figure to $22000 and that the inclusion of the Watchemoket Fire District in the $15 000 stand-by service charge was fictitious since the town had not requested the service and therefore this proposed charge against the town was without consideration, unlawful and confiscatory and invalidated the whole schedule. He also claimed that the rate of 10 cents for the low-pressure water should have been increased to 15 cents, the same as the rate for large quantities of high-pressure water.

Mr. Rice argued also that the rules and regulations fixed in the order were unlawful and unreasonable. Under this argument, Mr. Rice attacked the rules governing extensions, claiming that consumers paid for the extensions and then paid a water rate that would carry the investment that they themselves had made.

Finally Mr. Rice stated that the Public Utilities Commission should have demanded a strict accounting. Here Mr. Rice said it was not so much a question of what had actually been invested in a plant, but rather what would be the fair value of a properly constructed plant furnishing a similar public service.

The Supreme Court of Rhode Island handed down its opinion on March 7, 1927, reversing the order of the Utilities Commission saying "that on a more complete presentation of facts it may clearly appear that the respondent is entitled to some advance in rates." The opinion stated further: "We feel that it is not unfair to say, that . . . the respondent water company has been conducted primarily as an adjunct of the business of the Glenlyon Print Works and secondarily as a public utility," and, "the conclusion is warranted that the so-called deficit may fairly be ascribed to the low rate that the owners of the water company were charging themselves for water which they were using in their own enterprise, the Glenlyon Print Works."

The company's solicitors on April 18, 1927, asked the Supreme Court for a chance to reargue the case for the purpose of raising a question, of the company's rights under the Federal Constitution. This request was denied by the Court. On July 21, 1927, the company's attorneys filed in the United States District Court, a suit in equity against the members of the Public Utilities Commission, seeking an injunction against the estab-

lishment of rates which are confiscatory, unreasonably low and in violation of its rights under the Federal Constitution. Judge Letts denied the company's motion for a temporary restraining order, but ordered that citation be returnable to the Federal Court on July 30, and that the hearing on a preliminary injunction before three Federal judges would be heard at a later date. This hearing was held on September 15, 1927, and the judges took the case under advisement, and on October 8, 1927, dismissed the case saying "it would amount to asserting that this court has original and plenary jurisdiction over rate making, and there is nothing more elementary than that the Federal jurisdiction over rates is based solely on denial of due process by State Tribunals."

While this legal battle was in progress, the Committee of Five appointed at the special town meeting in June, 1926, also engaged a local engineer, Mr. F. V. Waterman, to make a study of the water supply situation of the town, including both fire districts, particularly the question of improving the water supply for fire protection. Mr. Waterman's report to the committee dated June 5, 1927, included the recommendations made by the Municipal Protection Department of the New England Insurance Exchange, as found in their report of December, 1925; also a description of the two districts and their distribution systems. He pointed out the need of spending about $283 000 to provide necessary adequate fire protection in the Watchemoket District alone and similarly that an expenditure of about $111 000 would be required in the district supplied by the East Providence Water Company, including the installation of double the number of hydrants and the addition of about 19 000 ft. of 6- and 8-in. pipe to complete grids and to supply outlying districts not supplied at the time. He showed that this expenditure would be substantially reduced in the case of the Watchemoket Fire District if the two systems were to be consolidated and supplied from the water company system.

The East Providence Committee on Water Supply employed Mr. F. A. Barbour in June, 1927 to examine Mr. Waterman's report and make recommendations. Mr. Barbour's report dated August 1, 1927 pointed out the possibilities of the town purchasing the system of the East Providence Water Company. The committee made its report to the town meeting on November 14, 1927, stating that it was its belief that an initial outlay of $1 000 000 would purchase the plant of the East Providence Water Company and requisite water rights and provide the necessary fire-supply additions including 215 hydrants. No action was taken at this meeting but a special meeting was called on January 3, 1928 to vote on the proposition of the town acquiring the water company property for not more than $600 000 including certain land, and water rights at Hunts Mills, sold by the company to the Sayles Finishing Plants in 1922, and that the General Assembly be asked for authority to float a bond issue of $1 000 000 to acquire and develop a town-controlled water system. The vote was 250 in favor and 86 against the proposition.

The Sayles Estate reluctantly agreed with this committee to sell the water works for $575 000 and the adjacent property and water rights at Hunts Mills for $25 000.

The necessary legislation was passed by the General Assembly in March and April, 1928. The bonds were sold by the town, and the title to the property was transferred to the town on September 21, 1928. The town and the Sayles Finishing Plants, also entered into an agreement giving the town certain water rights as against those of the Sayles Finishing Plants as a lower riparian owner. At the next billing date, the water board increased the minimum charge and hydrant rates.

The Sayles Finishing Plants, feeling the necessity of insuring the continuity of its water supply, in 1926 remodelled and added to its own filter plant, and, of course, retained its own riparian rights on Omega Pond which it always had owned since its establishment in 1899, subject to certain rights of the town to take water up to a designated volume per day.

Soon after the Supreme Court's adverse decision of March 7, 1927, the water company decided to ask the Utilities Commission for a new hearing. The company employed Mr. John P. Wentworth of Metcalf & Eddy, and Mr. Nicholas S. Hill, Jr., to prepare valuations and rate schedules. The valuations and schedules were completed the latter part of the year, so that, had the town meeting of January 3, 1928 failed to vote to buy the property, the company would be in a position to file at once, its new schedule and to prove its case with engineer witnesses.

The purchase of this property by the town was the first step toward a unified supply and system.

The conclusions as to value found by Messrs. Wentworth and Hill as of December 31, 1926, after making deductions for customers' contributions, were as follows:

	Wentworth.	Hill.
Gross reproduction cost 1927 price	$1 665 000	$1 834 264
Net depreciated reproduction cost	1 379 000	1 569 711
Fair value	1 100 000	1 200 000

Appendix.

The meter rates in effect since 1893 were as follows excepting that rates under 10 cents were cancelled in 1920.

When the quantity of water is ascertained by meter, the charge will be as follows:

Gal. per day.	Cents per 1 000 gal.
1 000 or less	30c.
1 000 to 3 000	25c.
3 000 to 5 000	20c.
5 000 to 7 000	15c.
7 000 to 10 000	12c.
10 000 or more	10c.

A minimum charge of $10 per year, payable in advance, entitled the taker to 33 333 gal. of water.

The fixture rates, per year, were:

One family, one faucet	$5.00
One family, two faucets	7.50
Two families, one faucet	7.50
For each additional family	2.50
Hose	8.00
Hose with other fixtures	6.00
Public fire hydrants	20.00

On December 31, 1923, there were 2 315 meter accounts, 393 fixture accounts and 166 hydrants.

THE SHEPAUG TUNNEL, WATERBURY, CONN.

BY R. A. CAIRNS.*

[*Read April 10, 1929.*]

The handicap of persuading people of the necessity and wisdom of providing and increasing water supplies, still exists; but it is rapidly becoming less serious than the difficulty of finding additional sources of supply not already mortgaged by others. A leading authority in Connecticut was quoted not long ago as saying that in another ten or twenty years it would be practically impossible to obtain rights on any watershed in this State. Just what this will mean is not easy to predict. One suggestion has been made and seemingly with reason, that it will become advisable to create a State board or commission clothed with authority to hear representations from different communities as to their needs, and thereupon to apportion water resources,— possibly even reapportion them from time to time,— taking from one and awarding to another, to the end that the available supply may be used to the benefit of the greatest number.

In the smaller and more densely populated states, and in states where satisfactory supplies are limited, this problem may well become a very serious one.

Historical. When in 1893 Waterbury took the bold step — bold for a community of only about 30 000 people — of going fifteen miles into the hills of Litchfield County and starting the development of an 18-sq. mile watershed, one important consideration was the fact that still further to the north and northwest were other watersheds which would be economically accessible for an orderly increase in supply should the city grow to such an extent that the "West Branch" could not furnish enough water. The possible though improbable came to pass, and more water was required. But in the meantime other developments had taken place. By successive Acts of the Legislature the city was excluded from these adjacent sources, as well as from the upper reaches of its own Naugatuck Valley.

More than ten years ago it was felt that in view of these limitations proper foresight demanded the planning of a general scheme to insure the future water supply. It was then decided that rather than endeavor to have these restrictions removed, the better and more farsighted policy would be to arrange for the diversion of water from the Shepaug River, an important tributary of the Housatonic. The legal difficulties were formidable, both in prospect and at closer approach; and the physical obstacles were far greater than any the city had ever been faced with. Careful studies, however, resulted in the decision to make the attempt.

A long and interesting account could be given of the proceedings un-

*City Engineer, Waterbury, Conn.

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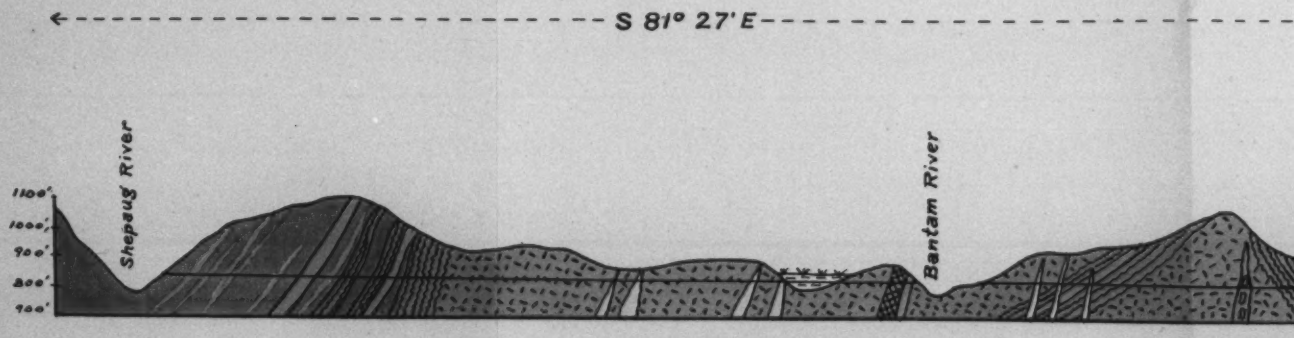
PLATE I.
N. E. W. W. ASSOCIATION.
VOL. XLIII.
CAIRNS ON
SHEPAUG
TUNNEL.

LEGEND

- Thomaston Granite Gneiss
- Mt. Tom Hornblende Gneiss
- Brookfield Diorite
- Hartland Schist
- Berkshire Schist
- Tunnel Line
- Strike and Dip.

½ 0 1
Miles
Contour Interval = 40ft.

CROSS SECTION THROU

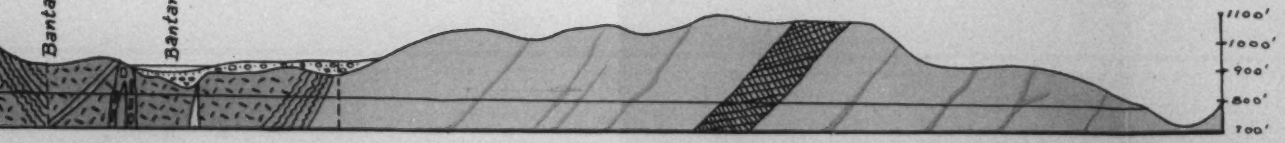


Scale
Vertical 1" = 500
Horizontal 1" = 2500

PLATE II.
N. E. W. W. ASSOCIATION.
VOL. XLIII.
CAIRNS ON
SHEPAUG
TUNNEL.

OUGH TUNNEL LINE

S 35° 46' E ---- S 81° 30' E



00'
00'

LEGEND

- Pegmatite Dikes
- Granite Dikes
- Biotite Hornblendite Dikes
- Diorite Porphyry Dikes
- Brookfield Diorite { Massive; Gneissic }
- Hartland Schist { Quartz + Mica Schist; Quartzite, Hornblende Muscovite, Garnet Schist }
- Berkshire Schist

dertaken and continued with the object of securing the right to divert the flow from 37 sq. miles of the upper Shepaug Valley. I believe that in many ways these methods were unique, both in concept and in execution; but let it suffice to say that though much time and patience were required the final outcome was most satisfactory. The credit is by no means all due to those who represented the city, for the owners whose property rights were infringed showed themselves singularly responsive to appeals made in the public interest. Sometime this chapter in the city's history should be written, if only to demonstrate that corporations can sometimes rise above considerations of selfish advantage.

I have referred to these matters, knowing that my readers would be moved to wonder why a city no larger than Waterbury should, in search of water, go so far afield and try to overcome such great physical obstacles, when less remote and less costly alternatives were available. The answer is that we were compelled to this course by legislative action.

The Shepaug Valley lies some miles northwest of our present West Branch watershed, and the intervening region is occupied by small valleys and high ridges which, as usually found in Connecticut, run north and south. Reservoirs can easily be created on the Shepaug for storage purposes, though the narrowness of the valley and its very considerable inclination make high dams necessary if large lakes are to be formed.

To get the water to the city, however, by gravity aqueducts would require either tunnelling or extremely long and very roundabout location over rugged and not easily accessible terrain, with no site for a suitable distributing and regulating reservoir near the city. In the end it was decided that it would be advisable to follow the shortest line to the existing chain of reservoirs in the West Branch Valley, a solution involving tunnelling the entire distance through rock. (Fig. 1 and Plates I and II.)

At first a straight line nearly due east and west was selected, beginning at a point on the Shepaug where a large dam could be erected (Fig. 2) and ending in the Pitch Brook Valley. When test drilling was begun, however, it was found that the basin of Bantam Lake where the line crossed, was far deeper than had been supposed, and that to keep the tunnel in rock would necessitate an inverted siphon a mile long, with a shaft 200 or more feet deep at either end. This was objectionable both on account of its cost and the loss of the advantage of a self-draining tunnel, in which inspection would be at all times feasible.*

Considerable reconnaissance was carried on with diamond drill crews

*Bantam Lake is the largest natural fresh water lake in the State and its beauty has attracted a large body of summer residents. These in turn have made a convenient market for the farmers of the region, and have added materially to the taxable property of two towns. From these conditions developed determined opposition to any taking of water from the lake or its tributaries by the city, and one of the legislative acts referred to.

When diamond drilling was in progress from a float on the lake, a strong suspicion developed in the minds of interested parties which took form in a belief that agents of the city, under pretense of exploration, were arranging to tap the lake and draw water from it into the proposed tunnel. With an inverted siphon, always full of water and therefore quite inaccessible, this fallacy could not easily have been controverted. On the other hand, a tunnel self-draining throughout, which can be entered any time on short notice, will be above suspicion.

and eventually another less direct line was found which gave promise of permitting a tunnel in rock at the required elevation. As much drilling as was considered to be economically possible was done on this line in the effort to locate the low point in the rock, geologists advising that a fault probably existed and a deep narrow gorge. This depression was found, and closely located; but it was not possible without excessive cost, to be sure that the very lowest place had been disclosed. The margin was small, but the risk

FIG. 1.—SITE OF PROPOSED RESERVOIR NO. 3 IN VALLEY OF THE WEST BRANCH OF THE NAUGATUCK RIVER. OUTFALL OF SHEPAUG TUNNEL IN FOREGROUND.

was taken; and the tunnel did not break through. This was very fortunate, as the tunnel was upwards of 175 ft. below the surface, in a basin filled with fine water-bearing sand, where air pressure could scarcely have been used to permit excavation.

Where holes were drilled on the adopted center line, the chief object was to determine the elevation of the surface of the rock. In some cases, however, these holes were continued to the grade line in order to ascertain the character of the rock to be excavated. An attempt was made to keep these deep holes plumb so that they would be of assistance in proving that the heading was on line. Although the drillman felt confident that these holes had been kept closely vertical, we found that at a depth of 100 to 200 ft. they departed considerably from a plumb line. Occasionally they were found somewhere in the heading and their position always raised the question as to whether the eccentricity was in the drilling or in the surveying.

Profile. Three grade lines were finally adopted for different sections of the tunnel. (1) From the western end to Bantam River the fall is about 1 in. for each 100 ft. This grade was used so that the tunnel would come to the surface at Bantam River, thus affording two intermediate and convenient working portals. (2) From this point the tunnel falls at the rate of 6 in. per 100 ft. in order to pass Bantam Lake Basin in rock, which it barely did. (3) From the lake to the discharge end the grade was again about 1 in. per

FIG. 2. — SITE OF PROPOSED DAM AND RESERVOIR ON THE SHEPAUG RIVER. WEST END OF SHEPAUG TUNNEL AT RIGHT.

100 ft. It was desired to have the outlet just above the flow line of the proposed Reservoir No. 3.

Power Plant. In working the tunnel, steam-driven machinery was mainly used. This was decided upon partly because a long power line would have had to be constructed to reach either the inlet or outlet end of the tunnel, where plants were required, and partly for the sake of independence. At the main power plant on Bantam River, from which operations were carried on both east and west, considerable power and light current was bought from the local company, to supplement that generated by steam.

The compressors used were Ingersoll-Rand horizontal duplex compound of various sizes, ranging from 400 to 1 200 cu. ft. of free air per minute, maintaining 100 lb. per sq. in. pressure in the receivers. Steam-driven generators furnished current for lighting, for motors on ventilating fans, in carpenter and machine shops, for charging batteries, and for other purposes.

Pumps were either horizontal duplex driven by compressed air or centrifugal directly connected to electric motors. Both types gave excellent service.

The first power plant was the smallest, erected at the west portal, on the Shepaug River in 1922. Expected to cover only an experimental section from 1 000 to 1 500 ft. long, it successfully served in the excavation of more than 6 000 ft. This plant was afterward transferred to the east portal, reinforced with a new and larger compressor and used satisfactorily in driving a section 11 357 ft. long.

The main plant at Bantam was equipped with three 100-h.p. Erie Economic Type boilers carrying 150 lb. per sq. in. pressure. Two compressors were installed, one with capacity for raising 800, the other 1 200 cu. ft. per minute of free air to 100 lb. per sq. in. pressure. These machines exhausted into an efficient condenser, so that they had the advantage of an excellent vacuum, usually maintained at 26 in. or better. Owing to the high cost of coal, it was deemed economical to go to some expense for equipment rather unusual in a contractor's plant. Besides using compounding and condensing machines, an adequate feed-water heater was installed. The boilers, water heater, and all live steam pipes were thoroughly insulated to reduce radiation, so that the Bantam plant looked more like a permanent factory installation than a temporary field power house. Most of this expenditure had to be charged to the cost of the work, salvage being of course small; but as operations were continuous for several years, during the driving and lining of 19 458.5 ft. of tunnel, and a good grade of steam coal cost $8.45 per ton at this plant, it undoubtedly resulted in considerable saving. At each of the three plants, blacksmith, machine and carpenter shops were provided and manned by competent workmen. Here again there is sound economy in having the very best men obtainable, even if unusually high wages must be paid. Really first grade blacksmiths and drill sharpeners are absolutely indispensable if good progress is to be made in rock tunnelling.

Cost of Coal.

At Bantam River	5 300 tons delivered @ $8.45 per ton	$44 785
At Shepaug	3 400 tons delivered @ $9.10 per ton	30 940
At Heminways	4 500 tons delivered @ $9.30 per ton	41 850
Total	13 200 tons	$117 575
Average cost per ton at boiler houses		$8.90

Ventilation. Considerable study was given to the subject of ventilation, especially to the relative advantages of the plenary and the vacuum methods. In the end it was decided to employ the second process which was continued throughout the operation. It appeared to us that this method afforded better general working conditions, all of the gallery being filled all the time with pure air, excepting some 300 ft. at the face immediately subsequent to blasting.

The plenary method, as opposed to this, keeps the greater part of the gallery more or less poisoned most of the time. It must be admitted, however, that blowing in air to the face probably facilitates earlier resumption of heading operations and so results in somewhat better progress.

In a minor way we did use the plenary process, the men on the dog shift carrying an air hose with them when they went up through the smoke to excavate a space at the face in which to set up drilling apparatus.

Organization. The work was directed entirely by the Municipal Bureau of Engineering, and was in charge of a resident engineer, and a corps of engineers and surveyors who also acted in the capacity of superintendents, inspectors and foremen. After some months of experimentation, it was decided that the work should be carried on in two shifts daily, each working about eight hours. Usually this meant that some of the men worked nine hours. The intervening periods of four or less hours were each utilized in getting rid of the powder gases, in replacing wires, and similar operations. Usually a force of three men, called the dog shift, went in early and cleared a short space at the face, so that the drillers could set up their machines and begin work without waiting for the muck to be removed. These men also did all obvious scaling of roof. Drilling and mucking then proceeded simultaneously.

Drilling. The drills used were Ingersoll-Rand 248s and gave good service. The usual layout of holes in good rock was a cut with three inclined holes starting some 30 in. either side of the center, two relievers depending on the hardness of the rock, rim holes and lifters. The exact number and arrangement of the holes was determined on each shift by the drill boss and the inspector, after observation of the face as left by the last shot.

The holes were loaded by the drill runners. Sixty per cent. special gelatine was used, of the kind developed by the DuPont chemists for use in confined spaces. This is expensive powder, but the resultant gas is less poisonous than that released by ordinary dynamite; as a rule, this is undoubtedly so. Electric exploders were used, instantaneous, first and second delays, with the firing box at least 700 ft. away. Current was taken from the lighting circuit.

After all exploder wires were connected up at the face, the circuit was tested by a galvanometer provided specially for this purpose. This resulted in very few failures when the firing switch was thrown.

This switch was inside a wooden box, closed and locked. The box was constructed with two safety devices, each of which made it impossible to close the door without breaking the circuit. A double-blade knife switch was placed near the top of the box and a detachable plug in the bottom. The only key to the box was always in possession of the shift foreman responsible for the firing. During the course of the work no premature explosion took place.

The usual procedure was to first fire the "cut"; afterward the re-

lievers with instantaneous exploders, the rim holes with first delays and the lifters with second delays. Ordinarily this process resulted in a good break with a hollow in the muck pile next to the face, making easier the work of the dog shift which was none too easy at best.

Before leaving the subject of blasting, concerning which a whole paper could be written, I wish to pay tribute to the traveling expert of the DuPont Powder Company. This man came at frequent intervals, and without

FIG. 3.— JUNCTION OF TUNNEL HEADINGS EAST OF BANTAM RIVER.

charge for time or expenses. He conferred with the author, after spending a whole day observing every detail of our handling and using of explosive and caps, freely answering all questions and giving advice of a most valuable nature. To this frequent and expert advisory service, our organization feels that it owes no small part of its immunity from casualties in the use of hundreds of thousands of pounds of high explosives.

Size of Bore. The tunnel was driven entirely with hand mucking, it appearing doubtful that economy would result from use of mucking machines in so small a bore. The economical size was difficult to determine satisfactorily. The original guess appears to have been a fortunate one, although it became a matter for endless discussion as the work went on. In the end this debate resulted in a small increase in size, but only a matter of one foot or less. In the Shepaug Tunnel rock, and for a small tunnel with hand mucking, the economical size appeared to be within the limits

of 7 ft. by 7 ft. or 7½ ft. by 8 ft.; with the advantage perhaps lying with the larger size.

No consideration of carrying capacity entered into a determination of the dimensions of the tunnel, since the economical size for driving gave an aqueduct much larger than there is any reason to suppose will ever be needed for the conveyance of water. This situation also eliminated any hydraulic considerations in connection with tunnel lining. (Figs. 3 and 4.)

FIG. 4.—WEST TUNNEL PORTAL AT BANTAM RIVER; BEFORE ERECTION OF BLOWER HOUSE.

Transportation. All transportation was effected in cars on a 24-in. gage track, with 4-ton storage-battery locomotives. The latter were products of the Atlas Car & Manufacturing Company of Cleveland and were very satisfactory. Their batteries were 40 cell, 80 volts, MVX 15 Exide, Ironclad, guaranteed for two years' service. In every case they served well beyond the guaranteed period.

At first a few steel muck cars were purchased, but they so soon became battered out of shape that we adopted the plan of designing and building our own. Wheels and axles were purchased, and bodies were built of native oak, well ironed. These cars proved extremely satisfactory, particularly after our mechanics had devised an improved form of journal which held grease better and excluded the destructive rock particles more successfully. Our cars cost $72.50 a piece as against $80.00 for steel cars.

Speed of trains was about five miles per hour. Possibly a somewhat higher speed would be economical, though it would also increase liability to accident.

Driving operations afforded an interesting illustration of the effect of

real live personal interest as exemplified in piece work and bonus. At the commencement of our operations, an advance of 6 ft. per round was apparently the limit of human endurance. At that, the mucking crew often got in several hours of overtime work, thereby increasing the pay roll per foot of tunnel, and incidentally postponing operations of the succeeding shift. By introducing a system of wages based on a minimum of 6 ft. of progress per shift, with pay increases in direct proportion to progress, and making the system applicable to all, drillers and muckers alike, the progress per shift rose steadily until 10 or 11 ft. was not unusual. One interesting fact was that whereas 7 or 8 men could not in the beginning load into cars the stone coming from 6 ft. of tunnel, under the bonus system 6 men regularly loaded all rock from 10 or 11 ft. of tunnel, and did it within the time limit of 8 hours.

Even after making full allowance for the numerous improvements in technique, and the results of organization and experience, it still remains true that the inducement of higher reward was mainly responsible for the surprisingly greater output. This was profitable for both owner and worker, the higher daily expense being more than balanced by the increased number of linear feet of tunnel driven. As one engineer expressed it —"the higher the pay roll, the lower the cost per foot of tunnel."

This, of course, brings up the old question of the effect on the individual of such high-pressure operation. Careful consideration was given to this phase of the work, and it was not found that the individual suffered. On the contrary, relieved from the inducement of spending as much time as possible in the tunnel in order to get more wages, he gave his whole mind to getting through quickly. Shorter hours of employment, coupled with higher profits, enabled him to live comfortably with his family at a distance from the work, to acquire an automobile, and in general to build up his resistance against the health hazards incident to his employment.

All operations of tunnelling, from first to last, were carried on by day work, under the direction of the bureau of engineering of the city of Waterbury. Of course, there was some disadvantage at the start, due to lack of experience in such work, but this was minimized by the fact that there was no great pressure to hasten the work, so that the early months could be utilized by proceeding slowly and cautiously in building up the working force and in learning the best methods. In the end, it is probable that the work was more carefully done than would have been the case under the contract system; the workman received more consideration and was better paid; and the cost was no more than it would have been under a contractor. It is therefore probably true that the city saved what a contracting organization would have figured as a reasonable profit. Considering that there was no small uncertainty as to the conditions which would be encountered, a sensible contractor must have provided in a unit-price proposition for both a substantial profit and for a further sizable sum that would secure him against loss should he meet conditions more difficult than anticipated. The

city, by adopting the day work method, insured itself against unexpected contingencies and happily won.

An interesting development during the course of our operations was the discovery that the distance between entrances could economically and in all respects satisfactorily be much longer than we had assumed.

It was originally planned to sink two shafts, one at each angle point near Bantam Lake. Since these shafts, with appurtenances, would involve a great expense and would be of no value after construction was completed, it was decided to do nothing about them until their provision should be found necessary. As construction progressed, it developed that the shafts were superfluous, either for facilitating transportation, improving ventilation or correcting alignment, and their omission resulted in a great saving in cost. With electric light and power, high-capacity ventilating fans and adequate air conduits, and with the improved storage battery locomotives drawing cars over well-kept tracks, the only limit to length of heading could perhaps be found in the saving of time resulting from more working faces.

Both the eastern and western headings made excellent connections, so close as to be practically exact. (See Fig. 3.) Only ordinary transits and levels were used from day to day by the men in charge of each heading, and by the special party which about once a month checked both line and grade. This checking was done at a time when no work of any kind was going on, the air was quiet and the lights were out.

The grade connections were surprisingly good, closer than the lines; this was not anticipated.

Character of Rock Penetrated. For many years geologists have shown much interest in the rock formations of western Connecticut and some have given especial attention to the so-called Bantam Basin. Very little opportunity for study of the rock other than as it appeared in outcrops was available until the driving of the Shepaug Tunnel. When this opportunity was called to the attention of Yale University it was eagerly seized upon, and resulted in frequent visits from Professor William M. Agar, of the Department of Geology. He quickly commended himself to the engineers and every facility was afforded him to examine the strata at any and all points.

In 1927, Professor Agar's observations were published by the State Geological and Natural History Survey in a fifty-page pamphlet known as *Bulletin No. 40.* From this able description it appears that several different strata were penetrated, the more extensive ones being Brookfield Diorite, Hartland Schist and Berkshire Schist. Narrow dikes of pegmatite, granite, biolite hornblende and diorite porphyry occurred at intervals, some of them of exceeding hardness. The occurrence and extent of these various rocks are accurately shown on Plates I and II, which also give the amount and direction of inclination of the various strata. No valuable minerals were found.

Progress of Tunnel Driving. Surveys and studies of the Shepaug as a possible source of additional water supply were begun ten years ago. Con-

struction of the Shepaug Tunnel was started in an experimental way in 1921, but not until some time later was it decided to drive the whole tunnel by day work. Progress by years was as follows:

Year.	Linear Feet.
1921	47.0
1922	1 331.6
1923	3 723.5
1924	8 228.8
1925	14 139.7
1926	10 123.0
Total	37 593.6

The last operation was building the east portal and outfall channel, completed on November 23, 1928.

Concrete Lining. It was hoped in the beginning that little lining of the tunnel would be needed, as the rock formation in this region, although greatly twisted and distorted and possibly on account of that condition, usually forms a self-supporting roof. In the end, however, a good deal of such lining was done, for a variety of reasons, a statement of which may be of interest.

The largest use of concrete was in giving the entire tunnel a masonry invert. Not originally intended, it was decided in the end that such a floor would be worth while, as resulting in (1) a completely draining surface, instead of a succession of pools and pockets, (2) easy walking even in the dark, and (3) particularly insurance against picking up of detritus by running water. (Fig. 5.) This consideration was felt to be important. At times it may conceivably be found desirable to pass a very large amount of water through the tunnel for a short period, producing velocities much greater than contemplated in normal service. Under these conditions the fine particles of stone composing the floor might be picked up, carried along and piled up in reefs which would be of considerable size. The accumulation of these barriers far from the portals would be troublesome.

In laying this concrete floor it was thought best to form it as the invert of a complete lining, so that if ever in the future such complete lining was thought desirable, the side walls and arch could be readily placed.

All sections of tunnel where timbering was found necessary or advisable during driving were given a full lining. There was somewhat more of this than had been anticipated. It was also decided to provide a complete lining for considerable distances where there seemed to be possibilities of future residence construction with chances of pollution from cesspools. This was not highly probable, but it was recognized that if such a situation should arise, the cost of doing the work would be far greater than if done when all equipment and organization were available. All complete lining, especially where sanitary reasons governed, was most carefully and thoroughly grouted.

An ordinary grouting machine was used, with a varying amount of air pressure, according to circumstances. In general it was found best to use the lowest air pressure which would introduce the grout, avoiding a tendency to use too much pressure. The mixture ranged from two parts of sand to one part of cement, where the space or seams to be filled were of large capacity, to neat cement in tight seams.

There were water-bearing seams and joints in the concrete so narrow

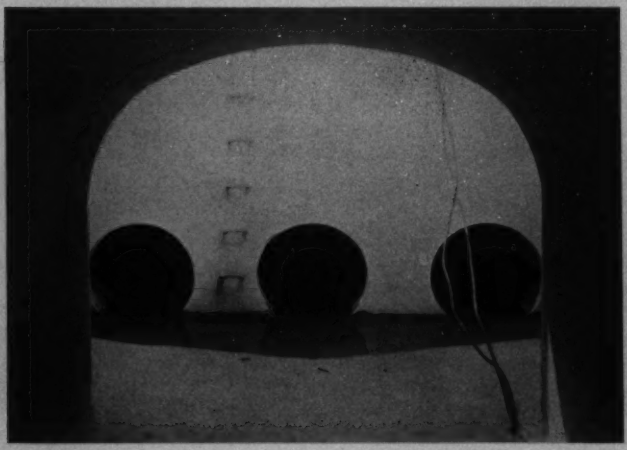


FIG. 5.— EAST END OF BANTAM RIVER SIPHON.

that it was not found possible to get enough neat grout into them even when 80 or 90 lb. per sq. in. of air pressure were used. To meet this condition an alemite gun was constructed and found effective. Just what pressure this put on the grout is not known; undoubtedly it was considerable.

All concrete was mixed outside the portals and transported in small steel cars in trains, usually six cars to the train. For the invert the concrete was dumped and spread with shovels. For the side walls and arch, which were built in one operation, a pneumatic concrete placer was used.

Steel forms were employed. For the invert the profiles and side forms to a height of 6 in. were designed and built on the job. Movable and adjustable forms for the side walls and arch were rented. (Fig. 6.)

No steel reinforcement was placed in the concrete lining. Owing to the very limited working space, all devices connected with pneumatic placing had to be designed and built especially for this job. Interesting studies and experiments were carried on in connection with the mixing of concrete so that segregation and solidification would not result from the vibration incident to long train carriage. Good results were obtained by thorough

mixing, large cement ratio, careful control of the water content and use of a small amount of Celite.

Health Hazards. One of the disquieting features of most large engineering undertakings is the toll which they take of human health and life. In spite of all precautions, and notwithstanding faithful efforts to provide the best possible working conditions, both inside the tunnel and in the camps, together with prompt medical service, some lives were lost and many hours of illness were recorded. Hundreds of accidents were reported, chiefly

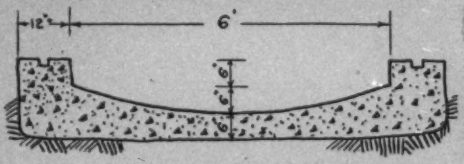


FIG. 6.— LINING OF INVERT.

of a minor nature, but requiring prompt treatment to prevent infection. This evil seemed to be always present, and was ascribed to the powder, whether justly or not I do not know.

It is generally admitted that pneumonia is an occupational disease in tunnel driving, and must be expected. All colds seemed to take on a serious form, and could not safely be neglected. To avoid them so far as possible a wash house was provided close to each portal, to be used by everyone when emerging from the tunnel. The temperature of this building was always kept around 80° F., with unlimited hot and cold water in sinks and shower baths. Separate wire-enclosed spaces were allotted to different groups, in which wet clothing could be left and found dry when next needed. Notwithstanding all this care several workers died of pneumonia.

Another constant menace was the effect of powder smoke. A certain amount of exposure to this smoke seems to be unavoidable and ordinarily is not especially dangerous. At intervals, however, and for reasons unknown to the powder specialists, exceptional amounts of dangerous gases are formed, and are present in the smoke. Men are overcome before realizing the danger, and become helpless. Concealed in the smoke cloud, their condition may not be noted for several minutes, and resuscitation then becomes difficult or impossible. Persons given to use of alcohol seem to have less resistance to these gases. It has also been noted, strangely enough, that an empty stomach is conducive to smoke sickness and diminished power of resistance to gas.

No lives were lost from accidents during the entire operation.

Costs. During the progress of the work careful records were kept of all expenditures, so that at all times the total cost to date was known, and also the cost of different kinds of work. The current value of these separate costs was as an indication of the trend, providing a constant spur to the

FIG. 7.— SECTION OF SHEPAUG TUNNEL CONDUIT IN RAVENSCROFT'S SWAMP WEST OF BANTAM RIVER.

organization, and a source of just pride when the figures showed a reduction.

Below are given final figures showing the total cost of the tunnel complete and ready for service, and also costs per foot of driving and lining.

DRIVING.

Item.	Lineal Ft.	Total Cost.	Cost per Ft.
Rock Tunnel	36 749.5	$1 584 510.52	$43.12
Earth „ (Shepaug only)	274.5	17 160.17	62.51
Totals	37 024.0	$1 601 670.69	$43.26

LINING.

Item.	Lineal Ft.	Total Cost.	Cost per Ft.
Concrete Invert	37 062.80	$371 739.88	$10.03
Concrete Arch	9 237.41	194 155.59	21.02
		$565 895.47	$31.05

SUMMARY.

Cost of driving	$43.26 per ft.
Cost of lining	31.05 per ft.
Cost of completely lined tunnel	$74.31 per ft.

None of these figures include the Ravenscroft's Swamp work (Fig. 7) which was carried as a separate item as follows: 569.6 lin. ft. of lined tunnel cost $146 323.75, an average cost of $256.89 per ft.

Cost of other work in connection with the tunnel was as follows:

All work between portals at Bantam River	$162 263.61
All work at Heminway Outfall	30 303.16
Grant total expended at Shepaug Tunnel	$2 506 456.68

These figures include the entire cost of equipment, the usefulness of which was practically exhausted, and 60 per cent. of cost of machinery still in good condition.

We have just completed another tunnel through similar rock, the purpose of which is to carry a new aqueduct through a ridge separating the West Branch Valley from Steele Brook Valley. This tunnel is 7 482 ft. long, and is completely lined with concrete masonry.

From January 1 to August 1, 1928, 362 drilling shifts averaged progress of fully trimmed tunnel of 9.86 ft. The record monthly progress was made in June, when 562½ ft. of trimmed tunnel were driven in 52 shifts, an average of 10.875 ft. The record weekly progress, 6 days ending March 16, was 141.8 ft. or an average of 11.82 ft. per shift. On June 25, 1928 two shifts made 24.5 ft. On March 7 one shift obtained the record by advancing 12.6 ft. This tunnel was driven entirely from one end, with one plant and one camp.

THE MAINTENANCE OF WATER METERS.

BY H. W. GRISWOLD.*

[*Read April 10, 1929.*]

The maintenance of meters is always a live problem with the management of water utilities, and as the number of meters and the cost of their maintenance increases, it becomes more and more important to so conduct the business that, on the one hand, too much revenue is not lost from out-of-repair meters, and on the other hand, too much is not spent on the upkeep of the meters themselves. Many factors must be considered in deciding upon a meter-maintenance policy which will be balanced properly between these two extremes, which will meet the requirements of the Public Utility Commission or other supervisory body, and which will not produce an undue number of complaints from customers. In the following paper, the author has endeavored to enumerate some of the more important parts of the meter-maintenance job with the hope that the presentation of such a list supplemented by brief descriptions of the way the various parts of the work are carried on at Hartford, Conn., will initiate a general discussion of the whole problem which will be of benefit to all.

In order to sketch the background, we must remember that there was a time when water was sold by the tap, water-closet, and bathtub, instead of by the cubic foot or gallon. The day of the flat rate was the day of cheap water; watersheds were ample; chlorination and filtration were not yet developed or were but words in the dictionary; and public utility commissions and boards of health were just coming into being. The villages grew into towns and the towns into cities, and the reservoirs and pumps finally became inadequate. At this point the water utilities divided into two groups. One group went in for increased rates and more reservoirs on the theory that when competition between communities for water resources came, it would have secured its share — and more — and could then curb waste and excessive use by metering. The other group subscribed to the doctrine of efficiency and went to metering first and to increased rates and more reservoirs later. Most of the larger utilities in both groups have come to the metering of at least a portion of their consumption. To some extent, therefore, we all now have a meter-maintenance problem.

Various types of meters have been brought out from time to time and have achieved some measure of popularity among water-works men, but in recent years it would seem that the disc meter in the smaller sizes has outdistanced all competitors and bids fair to become the standard measuring instrument for rates not exceeding 10 cu. ft. per minute. It is this type of meter in sizes from ⅝ to 1 in. which will be discussed in this paper. Al-

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though the product of one manufacturer differs from that of another in details of design and construction, disc meters are much alike. The three essential parts are (1) the measuring element, a hard rubber disc which oscillates in a chamber, (2) the counting mechanism or clock and (3) the gear train which translates the oscillating motion of the disc spindle into rotation and transmits this rotation to the drive wheel of the counting mechanism.

The early disc meters, like the early automobiles, lacked the refinements and smoothness of performance of the modern product and also, again as in the automotive industry, there was a development period when this or that feature was tried, found wanting, and something better substituted. Today meters are produced in quantity in factories that compare favorably in the use of labor-saving machinery and in efficient organization and management with any other industry. In the foundry, molding machines, flask and sand conveyors, the electric furnace, and the close and scientific control of metal mixtures are utilized to secure the maximum of sound and serviceable castings. In the other departments, devoted to the production of metal and rubber parts, many of the operations are performed by automatic machines, and even in those operations that cannot be performed automatically, such good use is made of jigs and fixtures that unskilled workers can readily make the pieces. At each stage of manufacture, rigid inspections are made for accuracy and quality, and after each meter is assembled it is given a flow test under both large and small rates of flow before it is shipped to the customer.

Meter maintenance really begins with the uncrating of the meter at the utility receiving room, for the methods of handling as well as the type and kind of setting have considerable influence on the subsequent performance of the instrument. Rough handling and exposure to extremes of heat or cold are not good for any make of meter and are to be avoided always. Some utilities make a flow test on new meters before putting them into stock or into service. This serves not only as a check on the manufacturer's product but detects any meters that may have been damaged in transit or after delivery.

In setting meters two general methods are followed. One is to set the meter in the cellar of the building served, as close to the point of entry of the service pipe as possible. The other is to set the meter in a box or vault at the street line. Which is the better form of setting depends on climatic conditions, how often the meter is to be read, against whom the cost of the meter setting is assessed, the length and kind of pipe serving the building and the type of building. With either type of setting, brass tail pieces or one of the numerous patented types of settings may be used. At Hartford, most of the settings are in the cellars of buildings, and all new meters are tested before being set.

The costs of the different operations for the various sizes of meters are given in Table 1, and the number of meters handled is shown in Table 2.

TABLE 1.— METER COSTS, HARTFORD, CONN., 1928.

	Size—in.				
	¾	¾	1	1½	2
Testing new meters	.29	.31	.36	.52	4.23
Aver. cost of meter	8.55	15.00	23.20	40.67	78.00
Installing in bldgs.	3.37	3.84	4.84	8.41	9.30
Installing in box	25.41	26.34	28.80	(Incl. $8	for box)
Changing in bldgs.	1.35	1.50	1.38	3.36	8.11
Repairs and test (used meters)	4.45	5.20	7.81	12.39	18.49
Building meters					
Installing	3.95	...	...	...	...
Replace with perm. meter and repair and test bldg. meter	10.64	...	...	...	...

The above costs are expressed in dollars per meter.

TABLE 2.— NUMBER OF METERS HANDLED, HARTFORD, CONN., 1929.

	Size—in.				
	¾	¾	1	1½	2
New meters tested	275	400	78	50	3
Installed (new) bldg.	241	309	52	40	5
box	21	25	6	...	...
Changed in buildings	755	745	187	25	21
Used meters repaired	914	843	213	31	30
Building meters	317	...	...	...	...

The cost of the meter and all the meter costs incurred up to and including the first setting are properly chargeable to capital outlay, so that from an accounting standpoint, maintenance costs may be said to start as the meter-setting team drives away.

The problem of meter maintenance has a great many interesting ramifications and it is interlocked to a greater or less extent with practically all the other activities of the utility. Considered alone, however, the most efficient method of maintenance is the one which gives a minimum sum for the cost of keeping a meter in operating condition on each service, plus the value, at the established rates, of the water which passes through the meters unregistered. The maintenance-cost item in turn is the sum of the costs of the various kinds of work that go to make up the job of meter maintenance. Of these operations, some must be performed regardless of cost, while others may be curtailed or extended as desired or as funds permit.

A large part of the work, and a part that must be carried on continually, is the changing and repairing of meters reported as "down" or "not operating" by the meter-reading or inspection force. The stoppage of the meter may be due to plugging with rust or some other foreign substance, to mechanical trouble in the meter or injury from freezing or from hot water.

To remedy the trouble from any of these causes the meter must be removed from the service and taken to the shop for repairs. At Hartford a crew of two men with a light car is used for changing meters. For many years it was the custom to remove the meter, put a pipe nipple in its place, and when the meter had been repaired at the shop to make a second trip to put the same meter back in the service from which it had been taken. During the last year or two it has become the practice to take off a "down" meter and immediately replace it with a new or repaired meter from a small stock carried on the meter truck. This saves the second trip to the service and while it increases the clerical work somewhat, the net result has been a reduction in cost.

In the shop, two methods of procedure seem to be in general use. In the smaller shops, one man does the whole work of repairing and testing. In the larger shops, one man takes the meter apart and cleans it; a second inspects it, decides what repair parts are needed and requisitions them from the stock room; a third man assembles the meter with the new parts and adjusts it; a fourth man tests it; and a fifth man paints it and gets it ready for the stock room or for setting. This procedure follows in general the standard factory method of splitting up a task into a number of operations of which the individual worker performs but one. Some shops replace gear trains and registers as units and have one or more men whose job it is to repair these parts only.

A stock of parts must be carried for each make of meter to be repaired at the shop, and the tendency is for this stock to grow unduly large if not carefully controlled. Where only a few meters of one make are in use, it is sometimes cheaper to carry no parts for them but to ship them to the factory for repair. The stock room practice usually follows that in use for the withdrawal of other material than meter parts from stores, although some utilities do not keep a stock ledger for meter parts and do keep a ledger for main-pipe and service-pipe material. It is true of course that a meter stock consists of a great number of very small parts having a low price per unit and that the clerical work necessary to carry on a complete stores account for meter parts is a much larger percentage of the value of the stores than is the case with either main-pipe or service-pipe supplies.

In testing either new or repaired meters, one of the several makes of meter-testing machines is very generally used together with the necessary tanks and scales for determining accurately the quantity of water passed by the meter. A machine which tests one meter at a time usually suffices for a small shop, but as soon as more than three or four men are working on the repair of meters a machine that will test meters in groups of from five to eight is found to be more satisfactory.

Meter records are an essential part of any successful scheme of meter maintenance, but the cost of these is apt to mount along with the stock room costs if not watched. Records, no matter how interesting, which are not summarized at frequent intervals nor used regularly in the conduct of the

business should be viewed with a critical eye. No system can function without some form of work order, which is often made to serve as a report of the job when completed. All meter work must be reported in detail to the meter-reading department in order that the meter readers' books and the consumers' ledger may be kept straight and up-to-date, for it is on these in the last analysis that the utility depends for its income, the most important thing in many ways in the whole business. Whether it pays to keep a record of the kind, number and size of meter on each service or to keep a history card for each meter on which are noted all its goings and comings, the amount of water it has passed to date, all the tests that have been made on it and the cost in detail of each operation, are questions which have as many different answers as there are utilities. These meter life-histories are interesting to study, but from an operating standpoint it would hardly seem worth while to keep such close track of a ten to fifteen dollar article unless such records pay for themselves in pointing the way to economies in maintenance or in determining the most efficient make of meter to purchase. The latter use of the history is the one most often stressed, but it is doubtful if many meters are actually purchased on the strength of the records made by the early, and now obsolete, models.

There are certain repairs that can be made without removing the meter from the service. Chief among these are stuffing-box leaks and the replacement of the register glass cover. By having meter readers note the nature of the trouble in reporting a meter "down" it is possible to have these repairs in place taken care of by one man with a light car to take him from job to job, and thus a large part of the expense of removing and replacing the meter is avoided.

The frequency of reading meters is a factor to be reckoned with in meter maintenance. The cost of reading meters for billing purposes alone is not properly a maintenance charge, but often meters are read one or more times between billing dates for the dual purpose of detecting "down" meters and of locating meters which show excessive consumption so that the owners of the property may be notified and may either take steps to stop the excessive use or waste, or be prepared for an unusually large bill at the end of the period. The cost of these intermediate readings is in part at least chargeable to meter maintenance, and if the interval between readings is short enough it will be unnecessary to make additional inspections of small meters in place. In Hartford, the small meters are read every two months and the bills sent out every six months. Large meters are read and billed monthly. Interesting data on current practice regarding meter readers and meter reading in other southern New England cities are shown in Table 3.

It seems to be generally conceded that meters, even though they are apparently operating perfectly, should be removed, tested and repaired at intervals in order to keep them within reasonable limits of accuracy. In some states, Connecticut among them, this interval is determined by a

TABLE 3.— DATA ON METER READERS AND METER READING IN SOUTHERN NEW ENGLAND CITIES.

Number of Meters.	How often read.	Number of Readers.	Hours worked per Week.	Rate of Pay.	Meters read per Man.	Other Work done.
5 490	3 mo.	2	44	$30.00 wk.	100	Remove and reset.
7 560	Large 1 mo. Small 3 mo.	10	54	32.00 wk.	75–90	Inspect leaks.
9 480	3 mo.	3	44	5.75 d.	60	None.
9 950	Abt. 45 d.	3	44	32.00 wk.	90	None.
13 980	Hse. 3 mo. Com. 1 mo. Large 1 wk.	4	48	5.04 d. 5.36 d.	125	None.
15 390	Large 1 mo. Small 1.5 m.		41.5	5.00 d.	50	None.
22 000	1½ mo.	6	41.5	38.00 wk.	150	Inspect leaks.
22 400	Large 1 mo. Small 2 mo.	8	44	35.00 wk.	90	Inspect for meter repairs.
24 110	Large 1 mo. Small 3 mo.	6	44	30.00 wk.	90–100	None.
27 662	Monthly	10	40	42.00 wk.	100	None.
41 276	3 mo.	10	44	24–30 wk.	85	Inspect.
96 460	Large 1 mo. Small 3 mo.	31	38	25–34 wk.	49	None.

ruling of the Public Utilities Commission or similar regulatory body, and varies from about five to ten years. The lower figure is for Connecticut and the higher for New Jersey. In some cases the maximum quantity of water that shall be passed by a meter between regular tests as well as the time interval between tests is specified. For any utility not covered by a definite ruling regarding regular tests, the proper interval between tests can be determined from the costs of changing and repairing a meter, the rate charged for water, and data on the average performance of the makes of meters in use in the community over a period of years. The first two items are known or can be readily ascertained; but even where meter histories are kept, it is not easy to construct a performance curve that will be truly representative. Factory tests show that a meter may register on a $^1/_{32}$ in. stream after passing a million cu. ft. of water, and almost any water works can produce records of meters that ceased to function after passing ten thousand cu. ft. In general, however, it may be said that meters do not register more water than passes through them — consumers to the contrary notwithstanding — and that the longer meters run, the less accurate they are, the decrease in accuracy being a function both of the time in service

TABLE 4.— RECORD OF REGULAR METER TESTS, HARTFORD, CONN.

⅝-in. Meter.

Years since Last Test.	No. Meters.	Cu. Ft. Water Passed.	Average Test. Per cent. Registration.		Average Repair Costs.	
			⅛	Full Flow.	Labor.	Parts.
19–20–21	9	104 522	25.6	90.0	2.36	5.68
15–16–17–18	8	109 400	46.6	100.5	2.23	4.31
13–14	11	122 882	59.0	99.8	2.26	2.25
11–12	7	68 657	7.6	72.6	2.28	2.61
9–10	8	60 600	40.2	88.2	2.43	2.23
7–8	13	75 438	44.0	93.0	2.44	1.53
5–6	9	44 978	10.7	101.6	2.00	1.11
Total	65				2.29	2.71

¾-in. Meter.

Years since Last Test.	No. Meters.	Cu. Ft. Water Passed.	Average Test. Per cent. Registration.		Average Repair Costs.	
			⅛	Full Flow.	Labor.	Parts.
19–20–21	18	195 900	11.2	86.5	2.18	7.85
17–18	12	213 492	39.3	99.7	2.97	2.30
15–16	12	272 577	45.8	101.5	2.58	2.50
13–14	7	143 170	63.7	100.7	2.45	0.97
11–12	10	125 130	32.8	100.6	2.16	2.55
9–10	6	149 017	47.8	101.3	2.15	2.79
7–8	8	85 263	37.1	99.7	2.45	3.22
4–5–6	10	104 890	26.7	98.3	2.33	1.56
Total	83				2.42	3.49

1-in. Meter.

Years since Last Test.	No. Meters.	Cu. Ft. Water Passed.	Average Test. Per cent. Registration.		Average Repair Costs.	
			⅛	Full Flow.	Labor.	Parts.
17–18–19–20	11	551 455	21.8	86.1	2.97	9.85
15–16	6	586 100	41.8	101.3	2.62	5.35
11–12–13–14	15	486 060	14.6	100.5	3.05	7.48
7–8–9–	8	510 588	....	99.6	2.92	5.65
4–5–6–	14	388 114	24.2	89.2	2.78	3.48
Total	54				2.90	6.42

1½-in. Meter.

Years since Last Test.	No. Meters.	Cu. Ft. Water Passed.	Average Test. Per cent. Registration.		Average Repair Costs.	
			⅛	Full Flow.	Labor.	Parts.
17–19	3	1 029 833	....	100.8	4.86	0.38
13	7	953 786	....	98.9	5.11	4.53
9–10–11–12	9	2 628 900	....	93.2	4.90	1.39
5–6	5	509 300	....	100.3	4.83	2.49
Total	24				4.94	2.41

and of the quantity of water passed. Some interesting figures, which are given in Table 4, were obtained recently from some regular tests of meters at Hartford.

The number of tests tabulated is too small to warrant the drawing of anything but the most general conclusions, and it is quite probable that another group of meters of similar ages and sizes would give entirely different average results. It would seem fair to state, however, that these figures indicate that the average accuracy of a meter after 10 to 18 years' service is not as low as might be supposed, and that the cost of repairing meters does not increase appreciably with their age.

In conclusion, and as a summary, it may be said that the five factors which have the most effect on the cost and efficiency of small meter maintenance are:

(1) Frequent inspection of meters in service to detect those not registering and those over-registering.
(2) The prompt removal and replacement of "down" meters with a minimum of lost motion.
(3) The testing of all meters at regular intervals.
(4) The application of efficient factory methods to the repair shop and the testing bench.
(5) Close control of records and stock so that there will be enough, but not too much.

INSTALLATION AND CARE OF VENTURI METERS.

BY A. B. COULTERS.*

[*Read April 10, 1929.*]

Installation. For water-works service, the installation of a Venturi meter tube presents no greater difficulties than the installation of an equal length of pipe. In fact a Venturi meter is easier to place than straight pipe, because it is made up of three or more sections which can be handled separately and bolted or leaded together in the trench. The inlet and outlet ends can be furnished with bell, spigot or flange joints as requirements demand. Where ground conditions are such that settlement may occur, tubes should be made with bell and spigot instead of flange joints on the outlet cone. Bell and spigot joints are also desirable where a high ratio exists between the inlet and throat diameters. In case this ratio is large the tube will have large ends and a small cross section at the throat. This structure, considered as a beam, does not possess great strength; hence a joint that will be somewhat flexible and relieve bending stresses at or near the throat is desirable. The center line of tube need not be horizontal; it can be inclined or even vertical. Tubes are usually placed directly in the line and become one of its permanent parts. Where the main line is much larger than the draught through it requires, mud or silt may in time collect along the bottom of the pipe. If, at any time, a heavy demand is made upon the line, this collection of silt may be picked up and carried along by the water column. Under these conditions, a Venturi tube having a throat amply large for normal or even abnormal flows may become inadequate and may temporarily even cause total stoppage of flow through the line. A better way to meter such a line is to build a by-pass around a gate and insert in this by-pass a Venturi tube of proper proportions. Under normal conditions the gate in the main line would be closed. When necessary, however, it could be opened to give full flow through the main line; naturally only the water passing through the by-pass would be measured.

Where tubes are to be built into lines under construction, the ends should conform to the pipe-laying scheme, that is, the bells should be laid upstream or downstream as the case may be. If the tube is to be placed in an existing line for which there is no exact knowledge as to how the pipe was laid, the tube should be ordered with spigots at both ends and should be inserted in the line by use of sleeves. It is essential that there precede the Venturi tube a section of straight pipe at least six times the nominal diameter of the Venturi tube for sizes up to 24 in., and at least 12 ft. long for larger sizes. No gate or fitting should be within this length to disturb the smooth flow of water. At the outlet end of the tube these precautions are

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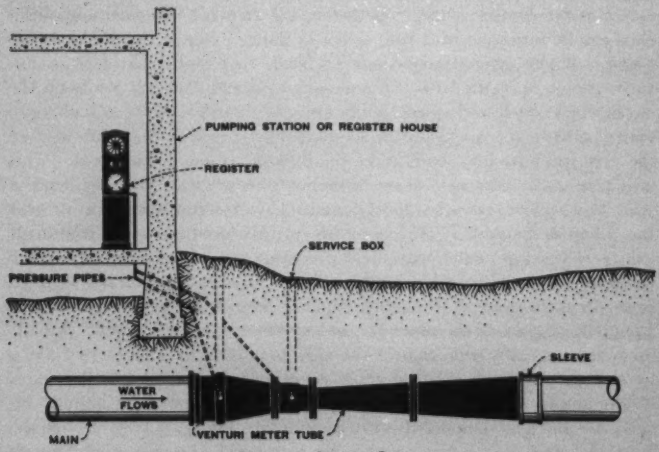
not necessary; the tube can be joined directly to reducers, increasers, bends or other fittings.

Provision for the examination and cleaning of Venturi tubes is not common. In water that carries iron in solution or finely divided clay in suspension these substances will in time coat the interior of the meter tube. Where such conditions prevail the installation of manhole tees at the inlet and outlet ends of the meter is necessary. Through these access to the interior of the tube may be had and cleaning accomplished by the use of scrapers.

The upstream pressure chamber and the throat pressure chamber are tapped for the insertion of corporation cocks. After these have been in-



TYPICAL VENTURI METER INSTALLATION.

serted, the tube may be placed under pressure leaving the completion of pressure lines until convenient. These lines are ¾ in. in diameter for lengths up to 50 ft. and larger for longer lines. Materials for these pipes in order of their desirability are as follow: (1) Brass or copper; (2) Lead; (3) Lead- or tin-lined wrought iron; (4) cement-lined wrought iron, and (5) galvanized wrought iron.

The lines should be so laid as to provide a continuous up or down grade between tube and register. They should be thoroughly blown out before they are connected to the register.

In most installations the registering instrument is located above the tube. Where this is so and where the line pressure is likely to drop suddenly, allowing the line to be partly or fully drained, the pressure lines upon leaving the tube should pitch sharply downward for a distance of about 2 ft. and should then rise toward the register. This is to prevent air

from entering the pressure lines and the recording instrument when the pressure in the line is restored. As there is no flow through the lines they should be protected against freezing.

Registers should preferably be installed in a light and dry location. Where this is not possible, means should be provided to drain and ventilate the chamber in which the register is placed. Provisions for heating should also be made. The back edge of the base of the recording instrument should be at least 6 in. from the wall and a space of at least 18 in. should be left on each side. Care should be taken to properly connect pressure pipes to the register, the upstream pipe to the upstream side of the register, and the throat pipe to the throat side of the register.

Care of Register. Register clocks and mechanisms should be oiled about twice a year with a good grade of clock oil, taking care to keep oil away from the integrating discs and wheels.

Two or three times a year the register should be tested by bringing it to "zero" and then to the "test point." This can be done in five or ten minutes. If the register does not check at the zero and test mark it should be opened and an examination made to determine whether the proper amount of mercury is in place. Cleaning may be necessary. If the register is of the "double float" type, special care should be taken to see that the screws in the rack gears are tight and prevent the turning of the gear upon the main shaft.

Stuffing boxes on the main shaft require but little attention. Occasional renewal of packing may be necessary; but this is seldom called for oftener than once a year. No packing should be used except that furnished by the manufacturer. This is made of chamois, cup-shaped and specially treated. It is tight under pressure and frictionless.

Discussion.

Charles G. Richardson.* In selecting the kind of pipe for pressure pipes between tube and register, consideration should be given to the difficulty of repairing breaks, should they occur. Recently a water company in a middle western state discovered that a galvanized pressure pipe extending under a roadway had sprung a leak, with resulting error in the Venturi meter readings. Very difficult and expensive excavation was necessary to locate the break which was finally found to be due to rusting of the pressure pipe at the point of connection to the meter tube. The meter had been in service about twenty years. In a new installation where the tube will be permanently submerged in a reservoir 1-in. extra heavy copper tubing for the pressure pipes has recently been specified. At the meter tube the connection will be a 1-in. extra heavy corporation cock with a 1-in. extra heavy brass street elbow turning downward and connecting to the pressure pipe. The two pressure pipes will then be enclosed in and supported by an 8-in. split vitrified tile pipe.

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FACTORS IN THE DESIGN OF DISTRIBUTION SYSTEMS.

BY V. BERNARD SIEMS* AND D. BENTON BISER.†

[*Read September 20, 1928.*]

While distribution systems may be planned to satisfy all the recognized factors making for ideal hydraulic structures, the system actually constructed depends largely upon the funds available or upon the attitude of the financiers who supply the capital. Where the factors taken into consideration are confined to the construction cost of systems intended to distribute water for domestic purposes only, such layouts are often justified economically, but justification is based upon incomplete premises; due consideration has not been paid to all the factors that should be given weight. In this question of first costs versus ultimate benefit, those responsible for designs are generally grouped according to the source of the capital needed for the improvements, *i.e.*, whether the funds are supplied by small private interests or by large public utility operators, such as the water-utility parent companies and municipalities. In spite of this aspect of the problem and the fact that in the case of local private companies and small municipalities the ultimate benefit of model designs are sometimes disregarded for the more immediate charm of low first cost, the true economic design, which is also the proper physical design of distribution systems, depends upon fundamental technical factors that remain unaffected, except relatively, by cost as a major factor. This paper will, therefore, treat only of the fundamental factors governing proper design of distribution systems. For the purpose of illustrating the economy of proper design, however, first costs will also be discussed.

Before the design of a system is begun certain elementary facts must be known, the first of which is the practical objective of the contemplated water system; whether a limited and restricted area is to be served or whether the area has prospects of expanding; if expansion is reasonably expected, in what manner, at what rate and in what direction such expansion will take place; whether or not the development will be industrial, residential or whether the characteristic growth will be mixed or indeterminate. A second elementary factor to be recognized is the source of supply. Thought must be given to the available capacity and suitability of supply for the intended use; its general plan of distribution, whether gravity or pumped; the ultimate complete economic development of the chosen source of supply and probable utilization of additional available sources within the period of time considered for estimates of future requirements. A third elementary factor is concerned with metropolitan districting of the

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water-supply utility. Districting and creation of metropolitan utility areas is tardily receiving the attention which it deserves in the light of present trends in population growth. It is following the lead of giant electric-utility development work under the fostering of water-utility parent companies controlled by private capital. Hence in designing systems, sight must not be lost of the relation which the system will bear to neighboring communities, the district within whose boundaries it will be located, and water supply sources controlled through previous allocation.

These three factors are general to the problem of designing distribution systems and are necessary to its broad understanding before tackling the details of design. Yet while these general factors are important in determining the nature of the source and its usefulness to meet demands of future growth, the total distribution requirements, the total capacity and most advantageous geographical positions of primary feeders, reservoirs, pumping stations and filter plants, there are other factors which more directly concern the distribution gridiron.

In the *Journal of the American Water Works Association* for January, 1924, the authors presented a paper covering a study of distribution systems in which future fire-protection requirements were made the basis of design. The study embraced investigations to determine, (1) the quantity of water used in combating fires of varying magnitude for various types of buildings and city developments or neighborhoods; (2) the factors altering those quantities; (3) the relationship between those quantities and the quantities representing domestic consumption in different characteristic neighborhoods or developments; (4) the forecast of changes in neighborhoods and the effect of zoning restrictions on them and on future growth; (5) the economy of basing distribution system design upon future requirements; and (6) a method of calculating the probable future maximum water requirements. The investigations were pursued in a rather thorough-going manner in various areas of Baltimore City and environs, certain phases being conducted in coöperation with the engineers of the National Board of Fire Underwriters who were desirous of modifying the accepted but questionable practice of basing fire-protection requirements upon the single factor of population supplied.

The outcome of the study was the establishment by the authors of fire-protection requirements based upon the estimated future growth and characteristic development of a community as the fundamental principle governing the design of distribution systems. A formula was developed which expressed in equational form this principle and which had as its factors the probable fire area involved in a serious fire in any neighborhood, the height of buildings and their combustibility, the response of fire apparatus and a correction factor known as the "Baltimore equation" and developed by the authors to apply a relative value for conflagration or exposure hazard. The object of the formula was to render more reasonable the requirements which would be placed upon a water system according to the method

employed by the Underwriters. Yet the requirements as calculated by this method were sufficient to satisfy the most liberal demands of design, for they made allowances for the character of anticipated developments in determining the basic fire area.

In the beginning, application of the principles expressed by the new formula was restricted to the design of the distribution system of the Baltimore Water Works, but the method has since been given wider application. and other, more enterprising, studies have been conducted of the basic principles controlling proper design. These studies have covered both large and small privately operated and publicly operated water-works systems with the result that the writers are now prepared to offer modifications to their earlier findings.

Since 1924 the idea of metropolitan water-supply districting has become manifest; statistical observations of the use and life of industrial water-supply sources both inland and on the seacoast are available; the principle of economic development of one water source for water supply and for waste disposal has become better understood and applied, and the benefits of zoning for utility development have been recognized and use has been made of zoning regulations to control community expansion. All these phases have some degree of bearing upon the general considerations of distribution-system design. Observations of residential demand peaks have enabled the writers to work out a relationship between average daily, maximum daily and peak consumption as well as a comparison of peak domestic demands and fire-protection demands. It has been found that this relationship throws a new light on design fundamentals and hence has an important and direct bearing upon gridiron and distribution-system design. For these reasons the writers present a new or revised formula which they believe will aid in establishing a scientific rule for standardizing distribution-system design within moderate capacity limits.

Applying the 1924 method it was found that while it made the capacity demand of a large town somewhat less and more reasonable, the demand of a small town usually remained too great to be of practical use for controlling design. After a series of observations it was found that this inconsistency was due to the predominating character of community development with respect to total and daily per capita water consumption. In large towns, business communities or areas isolated for the purpose of investigation, the major portion of total consumption is found to be used industrially or commercially and the per capita consumption is relatively high. In these cases building areas are large and congested, and the fire hazard is great. Total water consumption is uniform from day to day and is not seasonal; it does not reflect the ordinary dry- or hot-weather increase and, being predominately industrial, normal changes in domestic consumption rates have no appreciable effect upon it. Thus, where the total water consumed is not subjected to domestic peak rates that are abnormal when compared with the 24-hour rate cycle, the quantity of water required for fire protec-

tion represents the maximum demand to be placed upon a gridiron and hence is the controlling factor of adequate design.

On the other hand, in residential neighborhoods and predominately residential small towns, where water consumption is predominately domestic, day to day rates vary considerably; dry- or hot-weather peaks are reached that cannot be compared with the average maximum consumption rate. Under these conditions the fire hazard is slight, in so far as serious fires are concerned, because fire areas are small and fairly isolated. Thus, when dealing with a distribution system designed to supply predominately domestic demands, it was found that insufficient capacity would be obtained if fire-protection requirements were made the basis of design. Statistics gathered during a period of five years indicate, when analyzed and averaged, that for residential communities:

Average daily consumption $\times$ 1.5 = maximum daily consumption.
Average daily consumption $\times$ 2.5 = peak rate of draft.

It should be borne in mind, however, that these multipliers represent averages and that the individual case may lie above or below them. Such variations will depend largely upon the rate charged for water consumed and the metering of services. Ordinary use of water, as well as leakage and waste, increases if the cost is too low to encourage plumbing inspection and repairs or frugal water consumption.

If unknown, the average daily consumption must either be measured or roughly estimated, for it depends upon many variables. If known, it may be estimated for any future year by applying the per capita consumption figure to the estimated population, provided consideration is given to all other factors that affect total consumption. Among these factors, apart from other perhaps local ones, are: (1) the cost of water to consumers and possible rate changes; (2) the racial characteristics of the consumers influencing their use of a purchased commodity; (3) weather and meteorological characteristics of the community; (4) the conservation measures applied by the water utility and possible changes in policy; (5) the possible effect of the development of other domestic utilities, such as public sewerage, street washing or other increased public use of water. But having established the average daily consumption estimate, the maximum for which to design the distribution system should be the stated peak rate of draft for the year representing the limit of economic investment in the improvements contemplated.

For large towns, except in the case of purely residential zones, or for industrial and transitional zones, the calculated future fire-protection requirements should be chosen as the basis of design. The method followed in calculating the capacity of the distribution system should be that detailed in the 1924 paper of the authors, bearing in mind that it is of prime importance to estimate accurately the character of future growth. No reason is seen at this time for altering the formula details of the earlier work,

although some values of the graphs have been revised and the diagrams put in somewhat different form. The only change suggested in regard to the method is that its application be restricted to large towns, industrial areas and factory settlements.

In the case of towns showing present mixed development characteristics, one or the other of these two methods should be applied. The reason for no compromise in the selection of the proper design fundamentals is that, by virtue of present developments showing mixed character, the area can be assumed to be in a transitional state. It should, therefore, show a tendency toward either residential or industrial domination, and hence determination of future characteristics is possible. Usually the community showing mixed characteristics is undergoing transition from low-value to high-value congestion of population and property.

Thus the design of distribution systems falls into three major categories, (1) the importance and relation of the contemplated system in the general scheme of water-supply development for particular geographic areas, (2) the character and future possibilities of the community for which the system is contemplated, (3) calculation of the required capacity of the system in accordance with one of the stated methods, based upon the development characteristics of the community.

The first and second categories are more or less abstract, but a limit may be set for the number of years in the future to which the estimate of character and future possibilities of the community is carried or projected. This limit will be determined by the economic amortization of the investment to be made. With a definite year limit, the estimates for the future may be fixed with a fair degree of accuracy.

Concerning the first cost of construction of the system designed, both domestic and fire-protection peak demands should be met for either class of development, the greater demand being chosen in either case. The domestic peak demand, which as has been shown is the controlling factor for predominately residential communities, is a more tangible requirement upon which to base design than is the probable fire-protection demand, because the former is the primary requisite for any water works, *i.e.*, the supplying of sufficient water for domestic purposes. Hence the cost of systems designed to supply the domestic demand need not be defended since it is an unalterable necessity.

In the case of industrial communities, however, where fire-protection requirements are the controlling factor, it is perhaps necessary to justify the first cost of systems designed to meet these requirements. The per cent. cost of a public water system for fire protection is not great. It may be found by reference to the formula $Y = \frac{147}{X^{0.31}} - 12.1$, in which Y equals per cent. of total cost and X equals population in thousands. But this cost is inversely proportional to population and hence relatively greater for small towns than for larger communities. Nevertheless, the relative cost for

small towns is not prohibitive but in reality small as compared with the benefits of lower insurance premiums, provision against the loss of life by fire, economic waste resulting from loss in business, unemployment and property damage. Small towns are usually dependent upon one industry which if crippled would destroy the economic life of the town itself. Furthermore, systems designed to serve the fire demand obviate the necessity of operating and maintaining house pumps in high buildings having large consumption drafts. What is still more important, the construction of mains of sufficient size to have a reasonable life saves the cost of replacement by larger mains after only a few years of use.

Pumping stations will not be discussed in this paper, as they are considered part of the general water supply system rather than the distribution system. May it suffice to say that in properly designed and well balanced distribution systems, mains will be sufficiently large to support extraordinary drafts whether or not the pumping station serving the system is operating.

Storage and consequent pressure support, afforded by balancing reservoirs or standpipes, are important as parts of distribution systems. Balancing reservoirs, particularly at the ends of long feeder mains and at the extreme boundaries of service zones are automatic pressure adapters, resulting in uniform performance of distribution systems under varying conditions of draft. The presence of these adapters makes possible the use of smaller feeders without increasing friction losses or adding other detriments to service. These reservoirs also provide reserve storage to carry over chance periods of pump breakdowns. For better distribution performance, however, it is recommended that storage be distributed among several small reservoirs rather than being concentrated in a single large balancing reservoir. Both balancing-reservoir storage and pumping-station capacity should be sufficient to serve adequately the system whose primary main sizes have been fixed by calculated maximum demands.

Although systems may be adequately designed by the methods described, they should be made still more reliable by the provision of a sufficient number of line valves so placed as to render maintenance of the pipe system practical and efficient, and to guarantee reasonable continuity of service by guarding against long lines of main being out of service by shutdowns. The proper number and distribution of valves is commensurate in importance to the provision of duplicate supply lines and looped feeder or primary distribution mains.

Because of the greater likelihood of mains being broken where traffic is heavy and because of traffic congestion and the importance of consumers in high value sections, valves on distributing mains should be spaced at intervals not exceeding 500 ft. This practice will protect the water utility from liability for damages due to broken mains. In other sections the spacing may be 800 ft., while on feeder mains the spacing may be increased to 1 200 ft. The required valves should be located at intersections and

there should be at least three valves at each fourway branch on mains of approximately the same size.

For systems designed on the basis of fire-protection requirements, it is important that the full capacity of the system be available at fire hydrants. Hence an adequate number of hydrants should be provided and so located as to concentrate the flow where needed. No better spacing could be recommended than that given in the code of the National Board of Fire Underwriters. With the quantity of water necessary for fire protection of characteristic areas determined, the code assumes a discharge of 500 g.p.m. from each hydrant and so fixes the number necessary. It is true that the modern fire engine discharges 750 to 1 000 g.p.m., but to make the use of hydrants more flexible it is recommended that a single hydrant be assigned a value of 500 g.p.m. Symmetry and system should be observed in the actual location of hydrants. They should be placed at street intersections in order to receive the support of tie-in mains and also to facilitate quick location by fire-fighting forces. For the latter reason they should, furthermore, be arranged symmetrically along mains and should be staggered to reduce the necessity of carrying hose leads across the street. All fire-hydrant branches should be provided with valves for use in case of damage to the hydrant.

Wherever it is impracticable to support long feeder or important transmission mains with lateral mains and gridirons, duplicate feeders should be laid. Looped feeders improve the capacity and efficiency of the system and are likewise a guaranty against interruption of supply and an aid to maintenance; they are keystones of the distribution system.

An otherwise excellent layout may fail if the distribution system is inadequately maintained. Efficient and constant maintenance must be provided if the entire benefit of an adequate distribution system is to be realized and the return on an investment in a properly designed and constructed system is to be enjoyed. A great aid to efficient maintenance is a systemized method of filing construction plans and recording distribution system changes, revisions and improvements. Record sheets should be maintained accurately up-to-date showing all important parts and appurtenances of the system, and measurements.

The design of distribution systems cannot be discussed adequately without making mention of zoning. In communities where well regulated zoning laws are in force, the work of the designer of distribution systems is greatly simplified, because he can more accurately foretell the type of future development of areas of population. Hence, zoning is a factor that reduces the degree of error in estimates of future possibilities, and so is a guarantee against costly replacements and enlargements in later years.

In proceeding with the mechanics of design determine whether or not the community to be served will be predominately residential at the termination of the period of time considered economic for the proposed investment. If the characteristics will be residential, calculate the average daily

consumption allowing 50 to 85 gal. per capita daily depending upon whether the area is purely residential or residential with small minor mercantile centers, and basing population upon estimated rate of future growth. Multiply the average daily consumption so calculated by two to obtain the required capacity of the gridiron. Design feeder mains of a size sufficient to deliver the required quantity to the gridiron at a velocity not greater than the critical velocity. Design secondary grid of 6- and 8-in. mains where tie-ins are greater than 1 000 ft. apart and of 6-in. mains where secondary grid is closely tied in.

If the characteristics will be commercial or industrial or mixed, the process to be followed is somewhat more complicated. In developments of these classes it becomes necessary to determine to what degree the development is commercial or industrial. Since a business community is relatively unstable, inasmuch as it changes to a more congested class reaching its limits of density in the high value commercial district, a schedule to enable the grading of such communities is here given and the various classes defined.

Class I. Commercial: Transitional from residential representing a division of 60 to 40 per cent. residential; typical store-front dwellings and minor congested areas of business houses.

Average Commercial: Distinctly showing business preponderance, few dwellings, some apartments and flats over business houses; congested smaller commercial and minor mercantile areas predominate.

Class II. Commercial: Congested pure commercial; large buildings.

High Value Commercial: Nucleus of the business section; highly congested; most dense property value; greatest fire hazard and exposure to conflagration.

Industrial: Industrial plants grouped more or less closely; individual hazards may be high but exposure not so great because of areas of vacant land or of water.

It is not good policy to assume an arbitrary demand for the purpose of determining the gridiron capacity for which to design; it is more accurate to solve each individual problem. However, to generalize average demands based upon average developments, gridiron capacities required for the various zones of development described above are show in Figure 1. These capacities serve to indicate the maxima sufficient to adequately protect areas as defined, assuming that the development of the area will have reached its limit of development. The minimum requirements are not fixed, in order that the reading of the capacity graph may be more flexible, *i.e.*, so that it may be more readily adapted to any area in any stage of development. While average commercial zones in large and small towns are of the same relative importance to each community, yet structural conditions, fire hazards and the relation of the fire-protection demands to the general consumption demand would be incompatible; the calculated maximum capacity for the average commercial zone of the small town might not be so great as that for the listed commercial zone of the large town. In

fact, in so far as capacities are concerned, quantities greater than the maximum for the second class of commercial district may usually be disregarded when applying the capacity graph (Fig. 1) to small-town conditions.

With regard to the fire hazards implied in the descriptions of the various

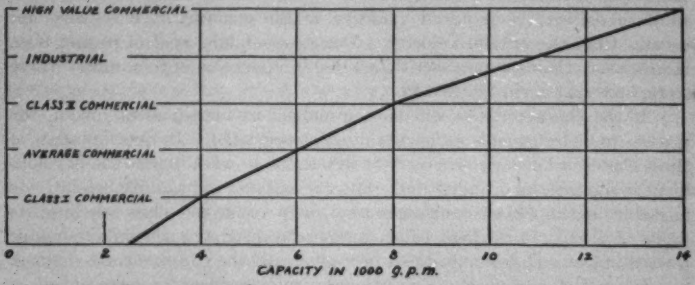

FIG. 1.— RECOMMENDED GRIDIRON CAPACITY FOR VARIOUS DEVELOPMENTS.

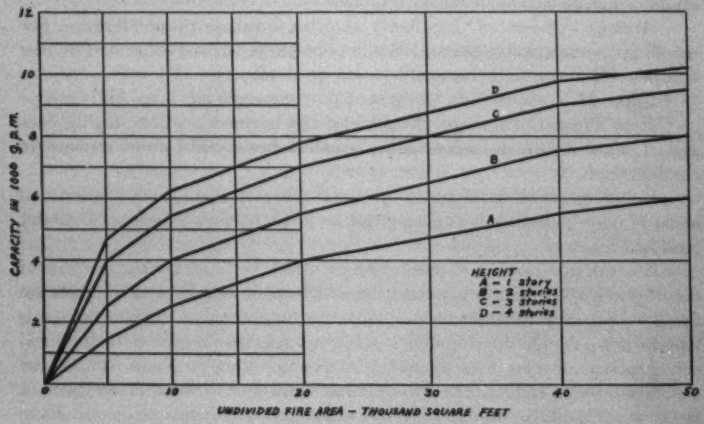

FIG. 2.— FIRE-PROTECTION DEMAND FOR AREA AND HEIGHT.

zones, those of the industrial zone are about the same as those of the second class commercial districts because of the fact that the exposure factor for industrial areas reduces the quantity of water required for fire protection. Generally speaking, land is not so congested with buildings as in the second class of commercial zone. But because of the partial isolation of industrial plants, the necessity of running long lines of hose to reach the seat of the fire and the fact that the manufacturing processes of many industries and

the material handled is highly combustible, the quantity demand for this zone has been made greater than that for the second class of commercial zone. For the small town, however, it is not recommended to consider demands greater than those of the second class of commercial district unless actual calculations so indicate.

Figures 2, 3, 4 and 5 are to be used in calculating the capacity for which to design gridirons in business or mixed areas, where fire-protection

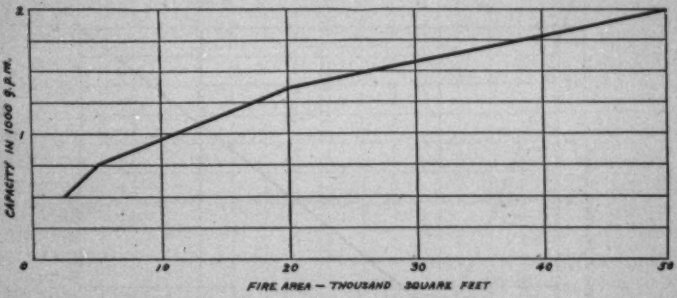

FIG. 3.— CORRECTION QUANTITY FOR COMBUSTIBILITY.

requirements are fundamental. The formula may be stated by the equation $Q = Q_1 \doteq Q_2 + Q_3 \doteq Q_4$, in which Q = the fire-protection demand or basis of design.

Q_1 = the quantity required for fire protection based upon the area and height of the probable largest fire area to be involved in a single fire or the greatest fire hazard.

Q_2 = a modifying quantity based upon the degree of combustibility of the fire area or contents of structures involved.

Q_3 = a surplus quantity based upon the proportion of water wasted in fire fighting.

Q_4 = a correction quantity based upon the exposure factor of surrounding areas to the fire area involved, or the "Baltimore equation."

In applying the diagrams for the calculation of gridiron capacity, proceed as follows:

By inspection in the field or from study of local zoning restrictions determine the probable future maximum fire area and hazard for the district or section of town under consideration. Read from Figure 2 the quantity required for that area and height of structure. The line for a four-story height may be taken as the limit; it represents the greatest demand as shown in Figure 1. Buildings higher than four floors are generally of modern fire-resistant construction, and fires occurring in them can usually be confined to four floors. By the undivided fire area is meant the total area included within walls of definite fire-resisting quality carried through the

entire structure and ending in a parapet wall well above the roof level; or it is the total area not separated from adjoining structures by open spaces sufficiently wide to prevent the spread of fire. It may embrace several buildings or an entire block.

Having thus obtained Q_1, read from Figure 3 the quantity corresponding to the fire area used for Q_1. If the building or its contents are highly combustible this new quantity, Q_2, is added to Q_1. If on the other hand the building or its contents are fire resisting, subtract Q_2 from Q_1. If the

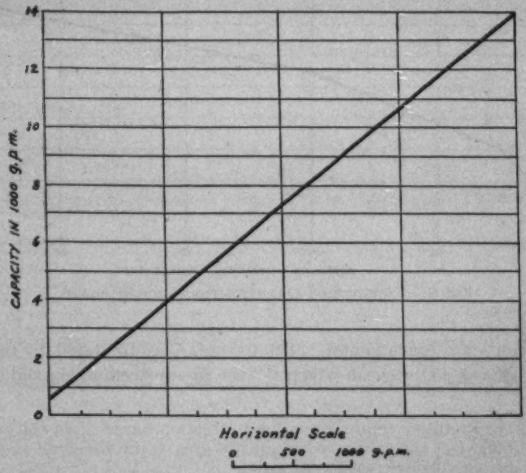

FIG. 4.— EXCESS CAPACITY FOR FIRE-ENGINE PUMPS.

combustibility of the building or contents are average in character Q_2 may be disregarded.

The purpose of Q_3, the next factor, is to compensate for the slippage of fire pumps, leakage in hose, and all water discharged from the distribution system during fire fighting which does not reach the fire or has no part in extinguishing the fire. Q_3 is then an allowance that is proportional to the total capacity of the fire-pump apparatus. To obtain this quantity, locate on Figure 4, using the values on the perpendicular ordinate, the point equivalent to the total capacity of the average number of fire pumps responding to a fire requiring the quantity of water previously calculated from Figures 2 and 3. Then locate a similar point on the graph for the quantity equivalent to the total capacity of all the fire pumps in the town that would be called from their stations for a single maximum fire. Drop perpendicular lines from these two points to the abscissa and read the horizontal distance

between these perpendiculars in g.p.m. according to the horizontal scale shown. Add this distance or quantity, Q_3, to the total obtained from Figures 2 and 3.

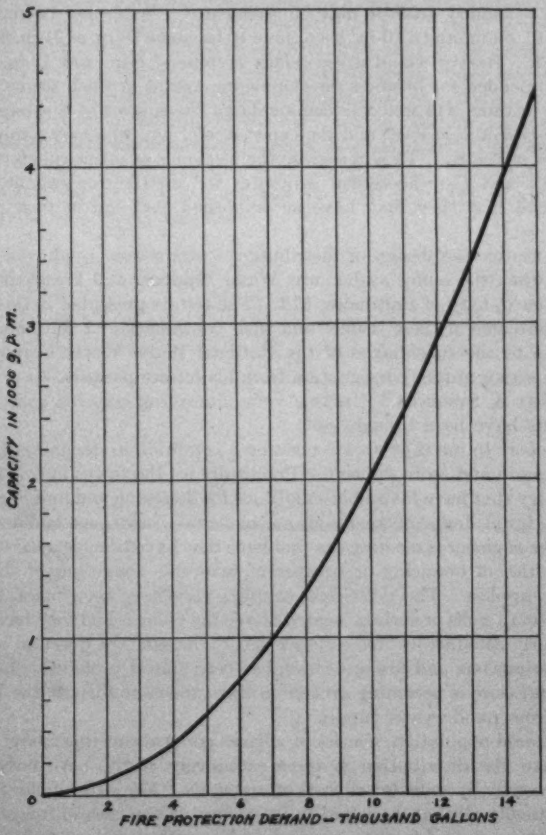

FIG. 5.— CORRECTION QUANTITY FOR EXPOSURE.

The total fire-protection demand thus far obtained, $Q_1 = Q_2 + Q_3$, is now referred to Figure 5, and the corresponding correction quantity read from the graph. If the surrounding and adjacent structures are exposed to fire from two or more sides of the fire area under consideration, the quantity obtained from Figure 5, Q_4, is added. If there is no exposure to adjacent property, Q_4 is subtracted. If exposure is on one side only, provided the

length of that side is not greater than one-fourth the perimeter of the fire area, Q_4 is disregarded. The algebraic sum of all the values Q_1, Q_2, Q_3, and Q_4 is Q, the capacity basis for the design.

The secondary gridiron may be designed of 10-, 12- and 16-in. mains; three 10-in. mains and a 16-in., then three 10-in. and a 20-in. or 24-in. primary grid main. Rarely would a secondary system of 8-in. and 12-in. mains be recommended for business developments, except in small towns.

The authors will welcome comments on the subject of this paper, the methods herein described, and the experience of any who may apply these principles of design. They recognize the need of a scientific rule to replace guesswork and too theoretical estimates for distribution-system design and believe that they may have accomplished that end in their present work.

Studies on the design of distribution systems were conducted by the authors when the senior author was Water Engineer and President of the Water Board, City of Baltimore, Md. The results presented in this paper are the outcome of these studies and their continuation at Baltimore, and expansion to the subsidiaries of the National Water Works Corporation, after the senior author's resignation from his former position.

HENRY A. SYMONDS.* In this very interesting paper a great many fine points have been brought out.

It occurs to me that we are meeting a condition in designing which is growing more and more difficult. Practically all the towns in this part of the country that have favorable conditions for designing and building water works, so far as financial conditions are concerned, have been taken care of. Today the engineer is meeting the problems that have been delayed because of difficulties of financing or because of favorable conditions of their individual supplies. The individual supplies may have been taken from a series of small wells or springs located above the villages and they have been giving fairly satisfactory domestic service. The sanitary question has not been a serious one and fire protection has been almost prohibitive in costs. But the pressure is becoming greater in these towns to furnish the benefit derived from public water supply.

Scattered population, a series of villages perhaps covering a large township, make the distribution systems excessively costly. We have been helped recently by some lower costs of materials. For a time following the war practically all that work had to be stopped in the class of towns which I am speaking of, and it was a pretty hopeless outlook for towns which had felt that they could not finance a large distribution system for a relatively small number of takers. That condition is improving somewhat.

Now, when the engineer attempts to lay out and design a new water works, he has too many unknown quantities to make it possible to meet all conditions exactly. They are the high sanitary standards, demands for better grade distribution system for fire protection, state regulation of

*Consulting Engineer, Boston, Mass.

finances and perhaps moderate financial ability of the town. The first condition must be satisfied but the others never can be fully.

So, to sum it all up, the design must be a sort of compromise or approximation to meet these conditions to best advantage. I think insurance rates are becoming more and more an important element in the design of water supplies, and this is being recognized and put upon a more scientific basis. Perhaps the towns and the insurance companies are getting a little nearer together and understanding better each other's position. I feel that the relations with the insurance companies of late are more flexible and that we have been able to get together with the insurance companies on more satisfactory plans. A few years ago we could not meet on any common ground or come to any agreement.

PUBLIC WATER SUPPLIES OF CONNECTICUT.*

BY WARREN J. SCOTT†
AND F. O. A. ALMQUIST.‡

In this paper statistics are presented relative to the various public water supplies of Connecticut. Some of the data, including miles of pipe and numbers of meters and services, are taken from the 1928 published report of the Public Utilities Commission of Connecticut. This report covers the year ending December 31, 1927. In some instances, data were available for the year ending December 31, 1928. Where the latter figures are used in the tabulation, they are so indicated.

Where no treatment is listed, none is provided. In the case of several reservoirs on one stream the immediate drainage area of each separate reservoir is usually given unless otherwise noted and does not include the drainage areas of upstream tributary reservoirs.

It should be noted that in addition to the supplies listed, there are several large institutional water supplies in Connecticut, as well as a few semi-public supplies in mill villages, furnishing water almost entirely to mill houses. There are also some small supplies that are used in summer colonies.

Ansonia.

Owned by: Ansonia Water Company. Introduced: 1868. Population: 19 200. Source: Peat Swamp Reservoir, Middle Reservoir, Quillinan Reservoir, Bungay Reservoir, King Street Brook, Fountain Lake, Connection with Birmingham Water Company. Drainage area: Peat Swamp Reservoir and Middle Reservoir, 1.1 sq. miles; Quillinan Reservoir, 0.8 sq. mile; Bungay Lake and King Street Brook, 0.6 sq. mile; tributary to Fountain Lake, 0.4 sq. mile. Reservoir area: Peat Swamp Reservoir, 73.5 acres; Middle Reservoir, 2.8 acres; Quillinan Reservoir, 13 acres; Fountain Lake, 6 acres; Bungay Reservoir, about 1 acre. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 36.3. Services in use: 2 488. Meters in use: 1 249. Per cent. of services metered: 50.2.

Avon.

Owned by: Avon Water Company. Introduced: 1910. Population: 500. Source: Nodd Brook. Drainage area: 2 sq. miles. Water supplied by gravity. Miles of pipe: 2.4. Services in use: 109. Meters in use: 0.

*EDITOR'S NOTE: This paper is the fourth in a series presenting statistical information on the Water Supplies of the New England states. For Massachusetts Water Supplies see Vol. 38, 1924, pp. 144-197. For Rhode Island Water Supplies see Vol. 40, 1926, pp. 117-127. For Maine Water Supplies see Vol. 41, 1927, pp. 99-128.

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‡Assistant Engineer, Bureau of Sanitary Engineering, Connecticut State Department of Health.

Beacon Falls.

Supplied by Seymour Water Company.

Berlin.

Supplied by New Britain Water Department.

Bethel.

Owned by Town. Introduced: 1878. Population: 3 500. Source: Wolf Swamp Reservoir, Mountain Pond, and Eureka Lake. Drainage area: Wolf Swamp Reservoir, 0.25 sq. mile; Mountain Pond and Eureka Lake, 0.6 sq. mile. Reservoir area: Wolf Swamp Reservoir, 20 acres; Mountain Pond, 15 acres; Eureka Lake, 37.5 acres. Water supplied by gravity. Treatment: Rapid sand filtration on Wolf Swamp Supply; slow sand filtration on Eureka Lake Supply. Miles of pipe: 15.9. Services in use: 575. Meters in use: 0.

Bloomfield.

Supplied by Hartford Water Department.

Branford.

Supplied by New Haven Water Company.

Bridgeport.

Owned by: Bridgeport Hydraulic Company. Introduced: 1853. Population: 170 000. Source: Aspetuck Reservoir, Hemlocks Reservoir, Upper Trumbull (Diversion to Easton), Easton Reservoir, Canoe Brook Reservoir, Island Brook Reservoir, Means Brook Reservoir, Boys Halfway Brook, Far Mill Reservoir, Trap Falls Reservoir. Drainage area: Aspetuck Reservoir, 16.91 sq. miles, tributary to Hemlocks Reservoir, 4.97 sq. miles; Upper Trumbull (Diversion to Easton), 4.8 sq. miles, tributary to Easton Reservoir, 12.8 sq. miles; Canoe Brook Reservoir, 1.61 sq. miles; Island Brook Reservoir, 1.24 sq. miles; Means Brook Reservoir, 5.16 sq. miles; Boys Halfway Brook, 2.15 sq. miles; Far Mill Reservoir, 6.14 sq. miles; tributary to Trap Falls Reservoir, .87 sq. mile. Reservoir area: Aspetuck Reservoir, 60.7 acres: Hemlocks Reservoir, 437 acres; Upper Trumbull Reservoir (Diversion to Easton), about 1 acre; Easton Reservoir, 734 acres; Canoe Brook Reservoir, 72.0 acres; Island Brook Reservoir, 69.0 acres; Means Brook Reservoir, 19.5 acres; Boys Halfway Brook, 0; Far Mill Reservoir, 59.6 acres; Trap Falls Reservoir, 296.0 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 407.7. Services in use: 29 115. Meters in use: 8 334. Per cent. of services metered: 28. Remarks: Several emergency supplies exist: Samp Mortar Reservoir; Horse Tavern Reservoir; Bunnells Upper and Lower reservoirs; Beaver Reservoir. These are practically abandoned.

Bristol.

Owned by: City. Introduced: 1884. Population: 27 500. Source: Reservoirs 1, 2, 3, 4 and 5. Drainage area: Reservoir No. 2, 0.4 sq. mile; Reservoir No. 3, 3.1 sq. miles; Reservoir No. 4, 1.74 sq. miles; Reservoir No. 5, 1.2 sq. miles; all tributary to Reservoir No. 1, 0.4 sq. mile. Reservoir area: Reservoir No. 2, 19 acres; Reservoir No. 3, 4.3 acres; Reservoir No. 4, 42.5 acres; Reservoir No. 5, 24 acres; Reservoir No. 1, 28 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 67.3. Services in use: 3 949. Meters in use: 4 276. Per cent. of services metered: 100.

Canaan (Falls Village).

Owned by: Falls Village Light & Water Company. Introduced: 1901. Population: 100. Source: Spring. Water supplied by gravity. Miles of pipe: 0.6. Services in use: 24. Meters in use: 0.

See also North Canaan.

Canton.

Owned by: Collinsville Water Company. Introduced: 1904. Population: 2 500. Source: Springs and reservoir at Huckleberry Hill and reservoir on Nepaug System, also connection with Nepaug Reservoir of the Hartford Water Department. Drainage area: Reservoir on Nepaug System, about 0.4 sq. mile. Reservoir area: Reservoir on Nepaug System, 1.5 acres. Water supplied by gravity. Treatment: Rapid sand, pressure filters on Nepaug Supply. Miles of pipe: 8.1. Services in use: 666. Meters in use: 69. Per cent. of services metered: 10.4.

Cheshire.

Supplied by New Haven Water Company.

Chester.

Supplied by Guilford-Chester Water Company; Chester Division.

Clinton.

Supplied by Guilford-Chester Water Company; Guilford Division.

Cornwall.

Owned by: Cornwall Water Company. Introduced: 1915. Population: 170. Source: Spring; emergency brook supply equipped with sand and gravel strainer. Water supplied by gravity. Miles of pipe: 1.34. Services in use: 39. Meters in use: 0.

Coventry.

Owned by: South Coventry Water Supply Company. Introduced: 1899. Population: 600. Source: Lake Wamgumbaug. Drainage area:

2.55 sq. miles. Lake area: About 350 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 1.87. Services in use: 73. Meters in use: 0.

Cromwell.

Owned by: Cromwell Water Company. Introduced: 1898. Population: 1 500. Source: Nook Pond. Drainage area: 1.1 sq. miles. Pond area: About 2 acres. Water pumped by electricity. Treatment: Chlorination. Miles of pipe: 6. Services in use: 245. Meters in use: 15. Per cent. of services metered: 6.1.

Danbury.

Owned by: City. Introduced: 1860. Population: 30 000. Source: West Lake, East Lake, Padanarum Reservoir, Upper and Lower Kohanza lakes. Drainage area: West Lake, 2.86 sq. miles; East Lake, 1.1 sq. miles, tributary to Padanarum Reservoir, 1.86 sq. miles; Upper Kohanza Lake, .33 sq. mile, tributary to Lower Kohanza Lake, 0.3 sq. mile. Reservoir area: West Lake, 239 acres; East Lake, 75 acres; Padanarum Reservoir, 9.5 acres; Upper Kohanza Lake, 30 acres; Lower Kohanza Lake, 6 acres. Water supplied by gravity. Treatment: Chlorination on Padanarum Supply. Miles of pipe: 41.2 (1928). Services in use: 3 500 (1928). Meters in use: 10 (1928). Per cent. of services metered: 0.3 (1928).

Danbury.

Owned by: Danbury Water Company. Introduced: 1849. Population: 150 (1928). Source: Deep well. Water siphoned from well. Miles of pipe: 0.2. Services in use: 27. Meters in use: 0.

Darien.

Owned by: Noroton Water Company. Introduced: 1911. Population: 4 400. Source: Buy from Stamford. Water supplied by gravity. Miles of pipe: 22.2. Services in use: 1 028. Meters in use: 1 028. Per cent. of services metered: 100.

Darien.

Owned by: Tokeneke Water Company. Introduced: 1909. Population: 250. Source: Dug wells; driven wells as emergency auxiliaries. Water pumped by oil engines. Miles of pipe: 2.1. Services in use: 100. Meters in use: 100. Per cent. of services metered: 100.

Derby.

Owned by: Birmingham Water Company. Introduced: 1859. Population: 11 000. Source: Great Hill Reservoir, and Derby Hill Upper and Lower reservoirs. Connection with Shelton Division of Bridgeport Hydraulic Company and Ansonia Water Company. Drainage area: Great Hill Reservoir, 2.6 sq. miles; Derby Hill Lower Reservoir, 0.6 sq. mile.

Reservoir area: Great Hill Reservoir, 13.2 acres; Derby Hill Lower Reservoir, 27.0 acres; Derby Hill Upper Reservoir, 9.6 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 23.8. Services in use: 1 437. Meters in use: 259. Per cent. of services metered: 18.

Durham.

Owned by: Durham Aqueduct Company. Introduced: 1798. Population: 200. Source: Spring with deep well as emergency. Water supplied by gravity; pumped electrically from deep well. Miles of pipe: 1.5. Services in use: 46. Meters in use: 0.

Durham.

Owned by: Durham Center Water Company. Introduced: 1911. Population: 100. Source: Fowler's Brook. Drainage area: 0.4 sq. mile. Reservoir area: 0. Water pumped by electricity. Miles of pipe: 1.0. Services in use: 24. Meters in use: 0.

East Hartford.

Owned by: East Hartford Fire District. Introduced: 1889. Population: 22 000. Source: Cold Brook Reservoir and Salmon Brook Reservoir. Drainage area: Salmon Brook Reservoir, 4.6 sq. miles; Cold Brook Reservoir, 6.25 sq. miles. Reservoir area: Salmon Brook Reservoir, 1 acre; Cold Brook Reservoir, about 6 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 74.5. Services in use: 2 637. Meters in use: 65. Per cent. of services metered: 2.

East Haven.

Supplied by New Haven Water Company.

East Windsor.

Owned by: Broad Brook Company. Introduced: 1895. Population: 500. Source: Deep wells. Water pumped electrically. Miles of pipe: 0.8. Services in use: 150. Meters in use: 0.

Ellington.

Owned by: Ellington Water Company. Introduced: 1862. Population: 300. Source: Brook. Drainage area: 1.25 sq. miles. Water supplied by gravity. Miles of pipe: 2.7. Services in use: 57. Meters in use: 0.

Enfield.

Owned by: Northern Connecticut Power Company; Thompsonville Division. Introduced: 1885. Population: 10 800 (1928). Source: Series of cased springs. Water pumped electrically; emergency gasoline engine. Miles of pipe: 32.6 (1928). Services in use: 1 931 (1928). Meters in use: 1 915 (1928). Per cent. of services metered: 99.

Enfield.

Owned by: Hazardville Water Company. Introduced: 1892. Population: 1 600. Source: Deep wells. Water pumped by steam. Miles of pipe: 6.0. Services in use: 266. Meters in use: 2. Per cent. of services metered: 0.8.

Essex.

Supplied by Guilford-Chester Water Company; Chester Division.

Fairfield.

Supplied by Bridgeport Hydraulic Company.

Farmington.

Owned by: Farmington Water Company. Introduced: 1881. Population: 1 000. Source: Wadsworth Reservoir. Emergency connection with Nepaug System of Hartford Water Works. Drainage area: 0.8 sq. mile. Reservoir area: 2 acres. Water supplied by gravity; emergency electric pumping connection with Hartford Public Water Supply. Treatment: Slow sand filters. Miles of pipe: 6.8. Services in use: 225. Meters in use: 264. Per cent. of services metered: 100.

Farmington.

Owned by: Unionville Water Company. Introduced: 1893. Population: 2 000. Source: Reservoirs No. 1 and 2. Emergency connection with Nepaug System of Hartford Water Works. Drainage area: 0.9 sq. mile. Reservoir area: Reservoir No. 1, about 0.5 acre; Reservoir No. 2, about 1 acre. Water supplied by gravity. Miles of pipe: 7.2. Services in use: 400. Meters in use: 23. Per cent. of services metered: 5.

Glastonbury.

Owned by: South Glastonbury Water Company. Introduced: 1905. Population: 650. Source: Impounding reservoir on Ackley Brook. Drainage area: 0.7 sq. mile. Reservoir area: Upper Reservoir, 4 acres; Lower Reservoir, 1 acre. Water supplied by gravity. Miles of pipe: 4.0. Services in use: 124. Meters in use: 5. Per cent. of services metered: 4.

See also East Hartford Fire District.

Granby.

Owned by: Salmon Brook Water Company. Introduced: 1872. Population: 165. Source: Bissels Brook. Drainage area: 6 sq. miles. Reservoir area: 1 acre. Water pumped by hydraulic rams. Miles of pipe: 1.5. Services in use: 62. Meters in use: 0.

Greenwich.

Owned by: Greenwich Water Company. Introduced: 1881. Population: 27 000. Source: East Branch of Byram River (Diversion to Put-

nam Lake), Pipen Brook, Rockwood Lake, Putnam Lake. Auxiliary pumping plant on Mianus River. Drainage area: East Branch of Byram River, 4.5 sq. miles; Pipen Brook, 2.2 sq. miles; Rockwood Lake, 1.0 sq. mile, all tributary to Putnam Lake, 1.6 sq. miles. Reservoir area: Putnam Lake, 90 acres; Rockwood Lake, 95 acres; Pipen Brook, 4 acres. Water pumped electrically to rapid sand filters and distributed by gravity. Mianus River pumped electrically to collecting reservoirs. Treatment: Water aërated and filtered by means of rapid sand and pressure filters. Chlorination provided. Miles of pipe: 101.5. Services in use: 5 300. Meters in use: 5 296. Per cent. of services metered: 100.

Griswold.

Owned by: Jewett City Water Company. Introduced: 1895. Population: 3 000. Source: Stone Hill Reservoir. Drainage area: 0.65 sq. mile. Reservoir area: 10 acres. Water supplied by gravity. Miles of pipe: 6.2. Services in use: 509. Meters in use: 4. Per cent. of services metered: 0.8.

Groton.

Owned by: Borough of Groton. Introduced: 1905. Population: 3 800. Source: Poquonock Dam on Great Brook. Drainage area: 15 sq. miles. Reservoir area: About 20 acres. Water pumped by water power, fuel oil, or electricity. Treatment: Chlorination. Miles of pipe: 19.5. Services in use: 1 064. Meters in use: 1 031. Per cent. of services metered: 99.

Groton.

Owned by: Groton Long Point Land Company, Inc. Introduced: 1900. Population: 1 000. Source: Wells. Water pumped by electricity. Miles of pipe: About 5. Services in use: 219. Meters in use: 0.

Guilford.

Owned by: Guilford-Chester Water Company. Introduced: 1900. Population: 18 000. Source: Killingworth Reservoir and Kelseytown Reservoir on Guilford Division; Chester Reservoir on Chester Division. Drainage area: Killingworth Reservoir, 1.2 sq. miles, tributary to Kelseytown Reservoir, 8.7 sq. miles; Chester Reservoir, 0.4 sq. mile. Reservoir area: Kelseytown Reservoir, 70 acres; Killingworth Reservoir, 87 acres; Chester Reservoir, 32 acres. Water supplied by gravity. Treatment: Guilford Division chlorinated. Miles of pipe: 83.4. Services in use: 3 476. Meters in use: 1 355. Per cent. of services metered: 39.0.

Hamden.

Supplied by New Haven Water Company.

Hartford.

Owned by: City. Introduced: 1856. Population: 209 000 (1928). Source: Nepaug Reservoir, Reservoirs Nos. 2, 3, 5 and 6. Drainage area: Nepaug Reservoir, 31.9 sq. miles; Reservoirs Nos. 2, 3, 5 and 6, 3.8 sq. miles. Reservoir area: Nepaug Reservoir, 851 acres; Reservoir No. 2, 44 acres; Reservoir No. 3, 25 acres; Reservoir No. 5, 32 acres; Reservoir No. 6, 141 acres. Water supplied by gravity. Treatment: Slow sand filters and aëration. Miles of pipe: 295.5 (1928). Services in use: 22 347 (1928). Meters in use: 21 823 (1928). Per cent. of services metered: 97.7 (1928).

Huntington.

Owned by: Bridgeport Hydraulic Company; Shelton Division. Introduced: 1879. Population: 7 410. Source: Reservoirs Nos. 1, 2 and 3. Connection with Trap Falls Reservoir of Bridgeport Division. Also connection with Birmingham Water Company. Drainage area: 1.3 sq. miles. Reservoir area: Reservoir No. 1, 20 acres; Reservoir No. 2, about 10 acres; Reservoir No. 3, 14 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 22.4. Services in use: 1 109. Meters in use: 123. Per cent. of services metered: 11.1.

Kent.

Owned by: Kent Water Company. Introduced: 1881. Population: 400. Source: Reservoir and spring. Drainage area: 0.2 sq. mile. Reservoir area: 0.5 acre. Water supplied by gravity. Miles of pipe: 0.75. Services in use: 83. Meters in use: 0.

Killingly.

Owned by: Powdrell & Alexander Company, Attawaugan. Population: 800. Source: Aspinook Brook. Drainage area: 0.4 sq. mile. Reservoir area: 0.75 acre. Water supplied by gravity. Miles of pipe: 2. Services in use: 161. Meters in use: 0.

Killingly.

Owned by: Crystal Water Company, Danielson. Introduced: 1887. Population: 4 800. Source: Hygeia and Chase reservoirs. Drainage area: Hygeia Reservoir, 0.4 sq. mile; Chase Reservoir, 1.7 sq. miles. Reservoir area: Hygeia Reservoir, 4 acres; Chase Reservoir, about 100 acres. Water supplied by gravity. Miles of pipe: 17.4. Services in use: 832. Meters in use: 59. Per cent. of services metered: 7.1.

Killingly.

Owned by: Williamsville Water Company — Goodyear. Introduced: 1889. Population: 1 000. Source: Alexander Lake. Drainage area: 1.2 sq. miles. Lake area: About 200 acres. Water supplied by gravity and pumping. Miles of pipe: 0.9. Services in use: 550. Meters in use: 0.

Litchfield.

Owned by: Litchfield Water Company. Introduced: 1891. Population: 980. Source: Reservoir on Griswold Brook and driven wells. Drainage area: 0.6 sq. mile. Reservoir area: 6 acres. Water supplied by gravity; pumped from wells by steam. Treatment: Sand and gravel filter strainer provided for surface supply. Miles of pipe: 10.6. Services in use: 300. Meters in use: 5. Per cent. of services metered: 2.

Madison.

Supplied by Guilford-Chester Water Company; Guilford Division.

Manchester.

Owned by: Manchester Water Company. Introduced: 1889. Population: 3 000. Source: Risley Reservoir and distributing reservoir. Drainage area: 2.1 sq. miles. Reservoir area: Risley Reservoir, 10 acres; Reservoir No. 2, 1.5 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 17.2. Services in use: 759. Meters in use: 14. Per cent. of services metered: 1.8.

Manchester.

Owned by: South Manchester Water Company. Introduced: 1890. Population: 14 000. Source: Howard, Porter and Roaring Brook reservoirs. Drainage area: Porter and Howard reservoirs, 1.4 sq. miles; Roaring Brook Reservoir, 4.7 sq. miles. Reservoir area: Howard Reservoir, 20.9 acres; Porter Reservoir, 7.4 acres; Roaring Brook Reservoir, 33 acres. Water supplied by gravity. Treatment: All supplies chlorinated; aëration and rapid sand gravity filtration on Roaring Brook Supply. Miles of pipe: 49.1. Services in use: 2 603. Meters in use: 2 699. Per cent. of services metered: 100.

Manchester.

Owned by: Highland Park Water Company. Introduced: 1910. Population: 160. Source: Shallow well supply. Water pumped by water power, steam or electricity. Miles of pipe: 2.5. Services in use: 40. Meters in use: 0.

Meriden.

Owned by: City. Introduced: 1869. Population: 32 000. Source: Merimere, Hallmere, Kenmere, Elmere, and Broad Brook reservoirs. Drainage area: Merimere Reservoir, 0.8 sq. mile; Hallmere Reservoir, 0.6 sq. mile, and Kenmere Reservoir, 1.5 sq. miles; tributary to Elmere Reservoir, 0.16 sq. mile; Broad Brook, 5.0 sq. miles. Reservoir area: Merimere Reservoir, 58.5 acres; Kenmere Reservoir, 30 acres; Elmere Reservoir, 4.5 acres; Hallmere Reservoir, about 20 acres; Broad Brook Reservoir, about 330 acres. Water supplied from Broad Brook by pumping

electrically. Water supplied from other reservoirs by gravity. Treatment: All supplies chlorinated; aëration and rapid sand gravity filters on Broad Brook Supply. Miles of pipe: 75.5. Services in use: 5 958. Meters in use: 2 639. Per cent. of services metered: 44.

Middletown.

Owned by: City. Introduced: 1867. Population: 18 000. Source: Mt. Higby and Laurel Brook reservoirs. Drainage area: Mt. Higby Reservoir, 2.06 sq. miles; Laurel Brook, 1.05 sq. miles. Reservoir area: Mt. Higby Reservoir, 82 acres; Laurel Brook, 72 acres. Water supplied by gravity. Laurel Brook Supply boosted electrically when used. Treatment: Chlorination. Miles of pipe: 47.9. Services in use: 3 124. Meters in use: 3 101. Per cent. of services metered: 100.

Milford.

Owned by: New Haven Water Company; Milford Division. Introduced: 1905. Population: 13 000. Source: Beaver Brook Reservoir. Drainage area: 1.3 sq. miles. Reservor area: 11.5 acres. Water pumped by steam. Treatment: Chlorination. Miles of pipe: 69.6. Services in use: 5 522. Meters in use: 2 063. Per cent. of services metered: 37.3.

Naugatuck.

Owned by: Naugatuck Water Company. Introduced: 1889. Population: 14 000. Source: Mulberry Reservoir, Upper and Lower Candee reservoirs, Prospect Reservoir, Straitsville Reservoir, Long Hill Reservoir and Twitchell Reservoir. Drainage area: Mulberry Reservoir, 0.79 sq. mile; Upper and Lower Candee reservoirs, 0.27 sq. mile; Prospect Reservoir, 1.3 sq. miles; tributary to Straitsville Reservoir, 0.22 sq. mile; Long Hill Reservoir, 2.79 sq. miles, tributary to Twitchell Reservoir, 0.1 sq. mile. Reservoir area: Mulberry Reservoir, 4 acres; Upper Candee Reservoir, 1.85 acres; Lower Candee Reservoir, 0.25 acre; Prospect Reservoir, 36 acres; Straitsville Reservoir, 2 acres; Long Hill Reservoir, 101.3 acres; Twitchell Reservoir, 0.75 acre. Water supplied by gravity. Miles of pipe: 43.7. Services in use: 2 155. Meters in use: 77. Per cent. of services metered: 3.

New Britain.

Owned by: City. Introduced: 1857. Population: 79 000. Source: Wolcott Reservoir, Shuttle Meadow Reservoir, White's Bridge driven well supply and Whigville Reservoir. Drainage area: Wolcott Reservoir, 2.3 sq. miles, tributary to Shuttle Meadow Reservoir, 2.09 sq. miles; Whigville Reservoir, 3.95 sq. miles. Reservoir area: Wolcott Reservoir, 49 acres; Shuttle Meadow Reservoir, 200 acres; Whigville Reservoir, 18 acres. Water supplied by gravity; auxiliary pumping from White's Bridge driven well supply into Whigville main. Treatment: Chlorination on all except White's Bridge driven well supply. Miles of pipe: 129.3. Services in use: 7 759. Meters in use: 7 606. Per cent. of services metered: 100.

New Canaan.

Owned by: New Canaan Water Company. Introduced: 1895. Population: 2 200. Source: Impounding reservoir on Five-Mile River. Drainage area: 1.1 sq. miles. Reservoir area: 20.8 acres. Water supplied by gravity. Treatment: Pressure filters and chlorination. Miles of pipe: 13.6. Services in use: 569. Meters in use: 9. Per cent. of services metered: 1.6.

New Hartford.

Owned by: New Hartford Water Company. Introduced: 1894. Population: 1 000. Source: New Hartford Reservoir. Drainage area: 1 sq. mile. Reservoir area: About 1 acre. Water supplied by gravity. Miles of pipe: 6.7. Services in use: 201. Meters in use: 25. Per cent. of services metered: 12.5.

New Hartford.

Owned by: Village Water Company. Introduced: 1825. Population: 800. Source: Spruce Brook. Drainage area: 1.5 sq. miles. Reservoir area: About 1 acre. Water supplied by gravity. Miles of pipe: About 1. Services in use: 43. Meters in use: 0.

New Haven.

Owned by: New Haven Water Company. Introduced: 1862. Population: 232 574. Source: Prospect Reservoir, Wintergreen Reservoir, Wepawaug Reservoir, Maltby Lakes Nos. 1, 2 and 3, Bethany Reservoir, Lake Chamberlain, Lake Watrous, Glen Lake, Lake Dawson, Lake Whitney, Saltonstall Reservoir, Farm River, Branford Reservoir. Drainage area: Prospect Reservoir, 1.5 sq. miles; Wintergreen Reservoir, 1.8 sq. miles; Wepawaug Reservoir, 7.7 sq. miles; tributary to the Maltby Lakes, 1.4 sq. miles; Bethany Reservoir, 3.8 sq. miles; Lake Chamberlain, 4.2 sq. miles; Lake Watrous, 3.2 sq. miles; Glen Lake, 1.6 sq. miles; all tributary to Lake Dawson, 0.8 sq. mile; Lake Whitney, 37.7 sq. miles; Farm River and Lake Saltonstall, 19.8 sq. miles; Branford Reservoir, 3.7 sq. miles. Reservoir area: Prospect Reservoir, 7.0 acres; Wintergreen Reservoir, 43.5 acres, Wepawaug Reservoir, 10.9 acres; Maltby No. 1, 22.9 acres; Maltby No. 2, 23.3 acres; Maltby No. 3, 25.8 acres; Bethany Reservoir, 101.4 acres; Lake Chamberlain, 35.1 acres; Lake Watrous, 109.1 acres; Glen Lake, 26 acres; Lake Dawson, 67.5 acres; Lake Whitney, 178.3 acres; Lake Saltonstall, 388 acres; Branford Reservoir, 10 acres. Water supplied by gravity and pumping by steam and electricity. Treatment: Chlorination on all supplies; also slow sand filters on Lake Whitney supply. Miles of pipe: 432.7. Services: 38 097. Meters in use: 21 636. Per cent. of services metered: 56.7.

Newington.

Supplied by Hartford and New Britain.

New London.

Owned by: City. Introduced: 1872. Population: 30 830. Source: Barnes Brook Reservoir, Bogue Brook Reservoir and Lake Konomoc. Drainage area: Barnes Brook Reservoir, 2.7 sq. miles; Bogue Brook Reservoir, 2.0 sq. miles, both tributary to Lake Konomoc, 2.5 sq. miles. Reservoir area: Bogue Brook Reservoir, 72 acres; Lake Konomoc, 225 acres; Barnes Brook Reservoir, 46.5 acres. Water supplied by gravity and pumping to high service by water power and electricity. Treatment: Chlorination. Miles of pipe: 79.9. Services in use: 5 347. Meters in use: 5 347. Per cent. of services metered: 100.

New Milford.

Owned by: New Milford Water Company. Introduced: 1875. Population: 3 000. Source: Reservoirs Nos. 1, 2, 3 and 4. Drainage area: Reservoir No. 4, 0.7 sq. mile; Reservoirs Nos. 1, 2 and 3, 1.0 sq. mile. Reservoir area: Reservoir No. 4, 5.2 acres; Reservoir No. 1, about 1 acre; Reservoir No. 2, 3.1 acres; Reservoir No. 3, 5.7 acres. Water supplied by gravity. Miles of pipe: 13.9. Services in use: 661. Meters in use: 0.

Newtown.

Owned by: Newtown Water Company. Introduced: 1906. Population: 600. Source: Taunton Lake. Drainage area: 1.1 sq. miles. Lake area: About 100 acres. Water pumped electrically. Miles of pipe: 6.3. Services in use: 143. Meters in use: 16. Per cent. of services metered: 11.3.

Norfolk.

Owned by: Norfolk Water Company. Introduced: 1895. Population: 1 500. Source: Lake Wangum. Drainage area: 1.5 sq. miles. Lake area: 300 acres. Water supplied by gravity. Miles of pipe: 12.3. Services in use: 371. Meters in use: 0.

North Canaan (Canaan).

Owned by: North Canaan Water Company. Introduced: 1879. Population: 850. Source: North Canaan Reservoir and dug well. Drainage area: 0.5 sq. mile. Reservoir area: 1 acre. Water supplied by gravity and electric pumping from well. Miles of pipe: 7.1. Services in use: 329. Meters in use: 44. Per cent. of services metered: 15.

Norwalk.

Owned by: First Taxing District. Introduced: 1870. Population: 12 000. Source: Scott, Brown and Grupe reservoirs. Drainage area: Scott Reservoir, 3.0 sq. miles; Brown Reservoir, 4.3 sq. miles; both tributary to Grupe Reservoir, 3.0 sq. miles. Reservoir area: Scott Reservoir, 16.2 acres; Brown Reservoir, 45 acres; Grupe Reservoir, 32.3 acres. Water

supplied by gravity. Treatment: Chlorination. Miles of pipe: 42.4. Services in use: 2 989. Meters in use: 1 831. Per cent. of services metered: 61.

Norwalk (South).

Owned by: Second Taxing District. Introduced: 1875. Population: 15 000. Source: North Wilton Reservoir, Huckleberry Reservoir, Wilton Reservoir, and emergency Silvermine Reservoir. Drainage area: North Wilton Reservoir, 6.42 sq. miles; Huckleberry Reservoir, 1.24 sq. miles; both tributary to Wilton Reservoir, 1.42 sq. miles. Silvermine Reservoir, 0.36 sq. mile. Reservoir area: North Wilton Reservoir, 3 acres; Huckleberry Reservoir, 39 acres; Wilton Reservoir, 135 acres; Silvermine Reservoir, 9 acres. Water supplied by gravity. Treatment: Aëration, slow sand filtration and emergency chlorination except on Silvermine Reservoir. Miles of pipe: 63.9. Services in use: 3 242. Meters in use: 137. Per cent. of services metered: 4.1.

Norwich.

Owned by: City. Introduced: 1869. Population: 28 500. Source: Meadow Brook, Fairview, Stony Brook and Deep River reservoirs. Drainage area: Meadow Brook Reservoir, 1.04 sq. miles; tributary to Fairview Reservoir, 0.95 sq. mile; Stony Brook Reservoir, 2.1 sq. miles; Deep River Reservoir, 8.5 sq. miles. Reservoir area: Fairview Reservoir, 80 acres; Stony Brook Reservoir, 69 acres; Deep River Reservoir, 124 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 65.1. Services in use: 5 005. Meters in use: 2 367. Per cent. of services metered: 47.

Old Lyme.

Owned by K. S. Hale & H. J. Hilliard. Introduced: 1911. Population: 400. Source: Wells. Water pumped by gasoline engine. Miles of pipe: 0.5. Services in use: 92. Meters in use: 0.

Old Saybrook.

Supplied by Guilford-Chester Water Company; Guilford Division.

Orange.

Owned by: Orange Water Company. Introduced: 1911. Population: 150. Source: Grassy Hill Reservoir and Wepawaug River. Drainage area: Wepawaug River, 7.7 sq. miles. Reservoir area: Wepawaug Reservoir, 10.9 acres; Grassy Hill Reservoir, 0.1 acre. Water supplied by gravity and pumping. Miles of pipe: 1.3. Services in use: 40. Meters in use: 0.

Plainville.

Owned by: Plainville Water Company. Introduced: 1884. Population: 5 000. Source: Crescent Lake. Connection with Whigville supply

of New Britain Water Department. Drainage area: Crescent Lake, 0.36 sq. mile. Lake area: 55.8 acres. Water supplied by gravity. Miles of pipe: 14.1. Services in use: 765. Meters in use: 753. Per cent. of services metered: 99.

Plymouth.

Owned by: Terryville Water Company. Introduced: 1893. Population: 3 135. Source: Reservoirs Nos. 1, 2 and 3, and driven well. Drainage area: Reservoirs Nos. 1 and 2, 0.03 sq. mile; Reservoir No. 3, 0.09 sq. mile. Reservoir area: Reservoir No. 1, 0.25 acre; Reservoir No. 2, 0.75 acre; Reservoir No. 3, about 4 acres. Water supplied by gravity and pumping by electricity. Miles of pipe: 15.1. Services in use: 572. Meters in use: 32. Per cent. of services metered: 5.6.

Portland.

Owned by: Portland Water Company. Introduced: 1889. Population: 3 300. Source: Portland Reservoir. Drainage area: 3.44 sq. miles. Surface area of reservoir: 23 acres. Water supplied by gravity. Miles of pipe: 18.4. Services in use: 752. Meters in use: 10. Per cent. of services metered: 1.3.

Putnam.

Owned by: City. Introduced: 1885. Population: 6 500. Source: Roseland Lake and Little River. Drainage area: Little River, 50 sq. miles. Reservoir area: Woodstock Pond, about 300 acres; Roseland Lake, about 300 acres. Water pumped by water power and electricity. Treatment: Rapid sand filtration and chlorination. Miles of pipe: 22.5. Services in use: 1 280. Meters in use: 68. Per cent. of services metered: 5.3.

Ridgefield.

Owned by: Ridgefield Water Supply Company. Introduced: 1900. Population: 2 000. Source: Round Lake. Drainage area: 0.6 sq. mile. Reservoir area: About 100 acres. Water pumped by electricity. Miles of pipe: About 10. Services in use: 492. Meters in use: 446. Per cent. of services metered: 88.4.

Rockville.

See Vernon.

Salisbury.

Owned by: Lakeville Water Company. Introduced: 1886. Population: 2 000. Source: Reservoirs Nos. 2 and 3. Drainage area: 1.3 sq. miles. Reservoir area: Reservoir No. 2, 3.0 acres; Reservoir No. 3, 0.75 acre. Water supplied by gravity. Miles of pipe: 6.5. Services in use: 370. Meters in use: 0.

Saybrook.

Supplied by Guilford-Chester Water Company; Chester Division.

Seymour.

Owned by: Seymour Water Company. Introduced: 1899. Population: 7 000. Source: Reservoirs Nos. 1, 2 and 3. Drainage area: 1.0 sq. mile. Reservoir area: Reservoir No. 1, 3 acres; Reservoir No. 2, 10 acres; Reservoir No. 3, 10 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 23.1. Services in use: 1 023. Meters in use: 57. Per cent. of services metered: 5.5.

Sharon.

Owned by: Sharon Water Company. Introduced: 1888. Population, 500. Source: Beardsley Pond, McCann Reservoir, Calkinstown Reservoir. Drainage area: Beardsley Pond, 0.4 sq. mile; Calkinstown Reservoir, 0.8 sq. mile; McCann Reservoir, 1.4 sq. miles. Reservoir area: Beardsley Pond, 30 acres; McCann Reservoir, 0.5 acre; Calkinstown Reservoir, 1.0 acre. Water supplied by gravity. Miles of pipe: 8. Services in use: 148. Meters in use: 12. Per cent. of services metered: 8.1.

Shelton.

See Huntington.

Simsbury.

Owned by: Simsbury Water Company. Introduced: 1874. Population: 150. Source: Grimes Brook. Drainage area: 0.8 sq. mile. Water supplied by gravity. Miles of pipe: 1.0. Services in use: 25. Meters in use: 0.

Simsbury.

Owned by: Village Water Company of Simsbury. Introduced: 1903. Population: 1 200. Source: Stratton Brook Upper and Lower reservoirs and No. 3 Reservoir. Drainage area: Stratton Brook Upper Reservoirs, 1.2 sq. miles, tributary to Lower Reservoir, 0.2 sq. mile; No. 3 Reservoir, 0.6 sq. mile. Reservoir area: Stratton Brook Upper Reservoir about 1 acre; Stratton Brook Lower Reservoir, about 1 acre; No. 3 Reservoir, 10 acres. Water supplied by gravity. Treatment: Aëration for No. 3 Reservoir and chlorination for all of supply. Miles of pipe: 12.0. Services in use: 371. Meters in use: 0.

Simsbury.

Owned by: Westover Plain Water Company. Introduced: 1901. Population: 125. Source: Spring. Water supplied by gravity. Miles of pipe: 2.3. Services in use: 32. Meters in use: 0.

Somers.

Owned by: Fuller & Hurd. Introduced: 1903. Population: 200. Source: Brook and spring. Treatment: Slow sand filter on brook supply. Drainage area: 0.8 sq. mile. Water supplied by gravity. Miles of pipe: 3.0. Services in use: 57. Meters in use: 0.

Southington.

Owned by: Borough. Introduced: 1884. Population: 8 500. Source: Reservoirs Nos. 1, 2 and 3. Drainage area: Reservoir No. 2, 1.03 sq. miles; Reservoir No. 3, 0.45 sq. mile, both tributary to Reservoir No. 1, 0.29 sq. mile. Reservoir area: Reservoir No. 2, 22.9 acres; Reservoir No. 3, 16.3 acres; Reservoir No. 1, 1.0 acre. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 43.8. Services in use: 1 700. Meters in use: 281. Per cent. of services metered: 16.5.

Sprague.

Owned by: Baltic Water Company. Introduced: 1909. Population: 1 500. Source: Baltic Reservoir. Drainage area: 0.25 sq. mile. Reservoir area: 2.5 acres. Water supplied by gravity. Miles of pipe: 3.5. Services in use: 380. Meters in use: 0.

Stafford.

Owned by: Northern Connecticut Power Company; Stafford Division. Introduced: 1886. Population: 3 800 (1928). Source: Reservoirs Nos. 1, 2, 3 and 4. Drainage area: 5.9 sq. miles. Reservoir area: Reservoir No. 1, 0.75 acre; Reservoir No. 2, 0.25 acre; Reservoir No. 3, about 10 acres; Reservoir No. 4, about 30 acres. Water supplied by gravity. Miles of pipe: 11.8 (1928). Services in use: 563 (1928). Meters in use: 605 (1928). Per cent. of services metered: 99 (1928).

Stamford.

Owned by: Stamford Water Company. Introduced: 1871. Population: 45 000. Source: Trinity Lake, Laurel Reservoir, Mead Pond, North Stamford Reservoir. Drainage area: Trinity Lake, 0.65 sq. mile, tributary to Laurel Reservoir, 2.8 sq. miles; Mead Pond, 3.36 sq. miles; all tributary to North Stamford Reservoir, 4.82 sq. miles. Reservoir area: Trinity Lake, 73 acres: Laurel Reservoir, 265 acres; Mead Pond, 45 acres; North Stamford Reservoir, 114 acres. Water supplied by gravity; pumping by electricity to Springdale. Treatment: Chlorination. Miles of pipe: 95.3. Services in use: 7 297. Meters in use: 6 483. Per cent. of services metered: 89.

Stamford.

Owned by: Shippan Water & Realty Company. Introduced: 1901. Population: 1 500. Source: Buy from Stamford Water Company. Water

supplied by gravity. Miles of pipe: 8.5. Services in use: 396. Meters in use: 396. Per cent. of services metered: 100.

Stamford.

Owned by: Springdale Water Company; controlled by Stamford Water Company. Introduced: 1907. Population: 2 500. Source: Supplied by Stamford Water Company. Water pumped by electricity. Miles of pipe: 7.1. Services in use: 682. Meters in use: 600. Per cent. of services metered: 90.

Stonington.

Owned by: Mystic Valley Water Company. Introduced: 1888. Population: 7 000. Source: Palmer Pond, Dean Pond. Drainage area: 5.8 sq. miles. Reservoir area: Palmer Pond, about 100 acres; Dean Pond, about 200 acres. Water pumped by electricity or steam. Treatment: Chlorination. Miles of pipe: 29.3. Services in use: 1 517. Meters in use: 48. Per cent. of services metered: 3.1.

Stratford.

Supplied by Bridgeport Hydraulic Company.

Suffield.

Owned by: Northern Connecticut Power Company; Suffield Division. Introduced: 1895. Population: 2 560. Source: Deep wells. Water pumped electrically. Miles of pipe: 11.8. Services in use: 349. Meters in use: 362. Per cent. of services metered: 96.

Thomaston.

Owned by: Thomaston Water Company. Introduced: 1881. Population: 1 474. Source: Reservoir. Drainage area: 0.75 sq. mile. Reservoir area: 45 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 6.9. Services in use: 383. Meters in use: 109. Per cent. of services metered: 28.5.

Thompson.

Owned by Grosvenordale Company; Masonville Spring Water Company. Introduced: 1915. Population: 3 000 (1928). Source: Dug well. Water pumped by electricity. Miles of pipe: 2.5 (1928). Services in use: 94 (1928). Meters in use: 94 (1928). Per cent. of services metered: 100 (1928).

Tolland.

Owned by: Tolland Aqueduct Company. Introduced: 1878. Population: 150. Source: Tolland Reservoir. Drainage area: 0.8 sq. mile. Pond area: About 1 acre. Water supplied by gravity. Miles of pipe: 1.4. Services in use: 36. Meters in use: 0.

Torrington.

Owned by: Torrington Water Company. Introduced: 1878. Population: 22 000. Source: North Pond, Hart Brook Reservoir, Lake Hatchaloosie, Whist Pond, Allen Dam, Marshall Lake. Drainage area: North Pond, 1.02 sq. miles, tributary to Hart Brook Reservoir, 5.02 sq. miles; Lake Hatchaloosie, 0.9 sq. mile; Whist Pond, 0.2 sq. mile, both tributary to Allen Dam, 2.08 sq. miles; Marshall Lake, 1.18 sq. miles. Reservoir area: North Pond, 200 acres; Hart Brook Reservoir, 1.5 acres; Lake Hatchaloosie, 25 acres; Whist Pond, 41 acres; Allen Dam, 2 acres; Marshall Lake, 22 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 49.5. Services in use: 3 714. Meters in use: 285. Per cent. of services metered: 8.

Vernon.

Owned by: Rockville Water & Aqueduct Company. Introduced: 1893. Population: 9 000. Source: Snipsic Lake. Drainage area: 17 sq. miles. Lake area: 624 acres. Water supplied by gravity and pumping by water power and electricity. Miles of pipe: 25.3. Services in use: 1 311. Meters in use: 607. Per cent. of services metered: 46.

Wallingford.

Owned by: Borough. Introduced: 1882. Population: 12 718. Source: Lanes Pond, Pistapaug Pond and Pine River. Drainage area: Lanes Pond, 0.5 sq. mile, tributary to Pistapaug Reservoir, 0.5 sq. mile; Pine River, 8.0 sq. miles. Reservoir area: Lanes Pond, 14 acres; Pistapaug Pond, 145 acres. Water supplied by gravity and pumping electrically. Treatment: Rapid sand filters on Pine River supply and chlorination. Miles of pipe: 43.5. Services in use: 2 138. Meters in use: 534. Per cent. of services metered: 25.7.

Washington.

Owned by: Judea Water Company. Introduced: 1898. Population: 170. Source: Springs and wells. Water supplied by gravity and pumping by electricity. Miles of pipe: 1.7. Services in use: 49. Meters in use: 1. Per cent. of services metered: 2.0.

Washington.

Owned by: Woodruff Water Company. Introduced: 1910. Population: 125. Source: Springs. Water supplied by gravity. Miles of pipe: About 0.5. Services in use: 31. Meters in use: 0.

Waterbury.

Owned by: City. Introduced: 1867. Population: 106 000 (1928). Source: Morris, Wigwam, Prospect and East Mountain reservoirs. Drainage area: Morris Reservoir, 13.8 sq. miles, tributary to Wigwam Reservoir, 4.6 sq. miles; Prospect Reservoir, 0.6. sq. mile, tributary to East Mountain

Reservoir, 0.6 sq. mile. Reservoir area: Morris Reservoir, 150 acres; Wigwam Reservoir, 105 acres; Prospect Reservoir, 28 acres; East Mountain Reservoir, 37 acres. Water supplied by gravity and pumped into high service. Treatment: Chlorination. Miles of pipe: 174.7 (1928). Services in use: 13 483 (1298). Meters in use: 12 800 (1928). Per cent. of services metered: 95 (1928).

Watertown.

Owned by: Watertown Fire District. Introduced: 1899 as Watertown Water Company. Population: 2 500. Source: Dug wells; Bethlehem Reservoir as emergency. Drainage area: Bethlehem Reservoir, 1.25 sq. miles. Reservoir area: Bethlehem Reservoir, about 5 acres. Water pumped electrically; emergency supply by gravity. Miles of pipe: 10.5. Services in use: 557. Meters in use: 17. Per cent. of services metered: 3.1.

Watertown.

Owned by: Oakville Water Company. Introduced: 1923. Population: 1 000. Source: Dug wells. Water supplied by gravity and pumping. Miles of pipe: 5.5. Services in use: 176. Meters in use: 222. Per cent. of services metered: 100.

Westbrook.

Supplied by Guilford-Chester Water Company; Guilford Division.

West Hartford.

Supplied by Hartford Water Department.

West Haven.

Supplied by New Haven Water Company.

Westport.

Owned by Bridgeport Hydraulic Company; Westport Division. Introduced: 1892. Population: 5 000. Source: Dug wells and supply of Bridgeport Hydraulic Company. Water supplied by gravity, and pumping by steam, water power or electricity. Miles of pipe: 37.7. Services in use: 1 164. Meters in use: 904. Per cent. of services metered: 95.

Wethersfield.

Supplied by Hartford Water Department.

Willimantic.

See Windham.

Winchester.

Owned by: City of Winsted. Introduced: 1862. Population: 8 000. Source: Rugg Brook with Mad River Diversion and Crystal Lake. Drain-

age area: Rugg Brook with Mad River Diversion, 10.8 sq. miles; tributary to Crystal Lake, 0.7 sq. mile. Reservoir area: Rugg Brook, 44.7 acres; Crystal Lake, 146 acres. Water supplied by gravity. Treatment: Chlorination. Miles of pipe: 22.1. Services in use: 1 292. Meters in use: 90. Per cent. of services metered: 7.

Windham.

Owned by: City of Willimantic. Introduced: 1885. Population: 12 500. Source: Natchaug River. Drainage area: 162 sq. miles. Reservoir area: 104 acres. Water pumped by water power and steam. Treatment: Chlorination. Miles of pipe: 28.9. Services in use: 1 927. Meters in use: 1 769. Per cent. of services metered: 90.

Windsor.

Supplied by Hartford Water Department.

Windsor Locks.

Owned by: Northern Connecticut Power Company; Windsor Locks Division. Introduced: 1892. Population: 3 000. Source: Brook. Drainage area: 2.0 sq. miles. Basin area: 0.4 acre. Water pumped by electricity. Treatment: Chlorination. Miles of pipe: 10.9. Services in use: 666. Meters in use: 280. Per cent. of services metered: 50.0.

Winsted.

See Winchester.

Woodbury.

Owned by: Woodbury Water Company. Introduced: 1894. Population: 700. Source: Reservoirs Nos. 1 and 2. Drainage area: 1.5 sq. miles. Reservoir area: Reservoir No. 2, about 2 acres, tributary to Reservoir No. 1, about 0.5 acre. Water supplied by gravity. Miles of pipe: 5.6. Services in use: 194. Meters in use: 0.

PROCEEDINGS.

FORTY-EIGHTH ANNUAL CONVENTION.

Portland, Maine.

September 17–20, 1929.

The following is a synopsis of such parts of the proceedings of the Portland Convention as appear to be of value for the record.

The Forty-eighth Annual Convention of the New England Water Works Association was held at Portland, Maine, September 17–20, 1929.

Hotel Eastland was the headquarters of the Convention. Here the technical sessions were held and here also were provided accommodations for the exhibits of Associates.

TUESDAY, SEPTEMBER 17.

Morning Session.

(*President Arthur D. Weston in the Chair.*)

THE PRESIDENT. The Forty-eighth Annual Convention will come to order.

First on the program is an address of welcome to Portland by His Excellency, the Governor of Maine. His Excellency could not be here this morning and has sent a letter of regret, which I ask Mr. Graham to read.

J. W. GRAHAM. The Governor is engaged at the Springfield Exposition and is unable to be with us today. He writes as follows:

STATE OF MAINE
OFFICE OF THE GOVERNOR
Augusta

August 23, 1929.

To Members of the New England Water Works Association:

I am glad to express the pleasure of our State as a unit, in welcoming you to Maine for your Convention. In Portland, the city of your selection for this occasion, you will be favored with much of interest, aside from the immediate duties to which you have been delegated. In other sections of our State, you will find equal hospitality and scenic beauties, both inland and along the coast line, and I hope that you will avail yourselves of visits to these various other vicinities, before your departure.

Maine citizens, in general, join in wishing you a happy and profitable session, together with the hope that you will come up and see us again.

(Signed) WILLIAM TUDOR GARDINER, *Governor.*

(*Applause.*)

THE PRESIDENT. It has been my privilege to participate in arrangements for several of our Conventions during the past few years. I do not think that at any Convention with which I have been connected we have had such full coöperation as the city of Portland has given us.

I want to introduce to you Mr. Lester F. Wallace, who is Chairman of the City Council of Portland, and who has a message for us this morning.

REMARKS BY LESTER F. WALLACE,

Chairman City Council, city of Portland.

Members of the New England Water Works Association, and friends: I should first like to explain why the Mayor of Portland is not here to greet and to welcome you this morning. It is because the city has no mayor. We operate under what is known as the council management form of government, the chief executive being the Chairman of the City Council. This position it is my privilege at the present time to occupy. I offer this explanation in order that you may know that our city official is here to greet and welcome you. Because of the ordinary familiarity with the term and title of mayor, I do not want anyone to feel that there had been any lack of appreciation of your coming to Portland. And so, as the Chairman of our City Council, I am most happy to greet you and to welcome you to Portland.

We have many advantages — and I say this without boasting — of which we are proud. Although we cannot lay claim to the source of our water supply being within our city limits, we are mighty proud of our water district and of our water. I am not a chemist and know very little about chemical analysis. All I can say, therefore, is that I think we have a splendid, pure and nice-tasting water. The only information I get along technical lines comes from our good friend, Mr. Moulton, of the Portland Water District.

We are very happy to have you with us, and we shall try to have the weather clear up so that you can enjoy the scenery.

I hope that you will have a pleasant and profitable Convention and that we may soon have you with us again. I thank you. (*Applause.*)

THE PRESIDENT. The Portland Water District has contributed very generously to our entertainment at this Convention. Several months ago it was my pleasure to come here with Mr. Robert Spurr Weston as guest of the Maine Public Utilities Association. At that time representatives of the Portland Water District extended an invitation to us to hold our Convention in this city. This invitation was so cordial that our Convention Committee felt that it should be accepted. The representatives of the Portland Water District are doing a great deal for our entertainment.

Mr. Blake, the President of the Board of Trustees of the District, is here this morning and has consented to speak to us.

REMARKS BY WILLIAM L. BLAKE,

President, Board of Trustees, Portland Water District.

Mr. President and gentlemen of the New England Water Works Association: On behalf of the Trustees of the Portland Water District, it is a pleasure and a privilege to welcome you to our city at this time, on the forty-eighth anniversary of your organization.

It is now thirteen years since we had a visit from you, and I am sure that your selection means that you have a warm spot in your heart for one of the finest cities in New England.

It is an inspiring sight to witness so large a number of representative men from all over New England, whose one and sole object is the development and the protection of the public health in the matter of pure water supplies. Portland is enjoying the advantages of one of the finest water supplies in the country. This is a statement which I do not think will be challenged because you are all aware that we have undoubtedly the cleanest and the nicest water that it is possible to obtain anywhere. Sebago Lake, Portland's source of supply, provides a gravity system. No filtration is necessary, and chlorination is used only to protect us against chance pollution. The Trustees have purchased land and cottages on both sides of the lake to within two miles of the intake, and the cottages have all been removed. We have reforested the territory and are protecting it as thoroughly as possible by strict sanitary regulations.

I understand that Sebago water is our visitors' delight. Many are the praises by them of its softness and its service as a fresh and invigorating quencher of thirst. It is even suitable for batteries when drawn direct from the tap. We cannot place too much stress upon the care with which we guard our water supply.

The Trustees invite you all to visit our modern work shops and to see our new and up-to-date equipment, including an emergency truck which is provided with everything necessary for our work. This truck is equipped with a powerful searchlight, which at a recent fire was found very helpful to our fire department.

Our general manager, Mr. Graham, will give you further details regarding the general condition of our system, and our attorney, Mr. Moulton, will tell you about its financial success. Our employees will be at your disposal, to give you all the information possible, and we wish and hope that you will have a most pleasant and prosperous time while you are with us. I thank you. (*Applause.*)

THE PRESIDENT. Before proceeding to the reports of the various committees, I have a duty which it is a great pleasure to perform. We have, as you all know, members in all parts of the world, and we have always had one or two members come from a considerable distance to our conventions. But to my knowledge nobody has come, during the past few years, from quite such a distance as one member who is here today. I have in mind

Mr. Aguirre, who is Chief Engineer of the Hydraulic Department of the Bureau of Public Works of Chile. I would like to have Mr. Aguirre stand so that you can all get acquainted with him. Mr. Aguirre. (*Mr. E. Aguirre stands, amid applause.*)

Administrative Reports.

The Secretary, Frank J. Gifford, submitted his annual report. (See page 337.)

The Treasurer, Albert L. Sawyer, submitted his annual report. (See page 340.)

The Editor, Gordon M. Fair, submitted his annual report. (See page 343.)

The Report of the Finance Committee was read by the Secretary. (See page 346.)

Upon motion from the floor, duly seconded, it was voted to accept these reports and place them on file.

Award of Dexter Brackett Memorial Medal.

The report of the Committee on Award of the Dexter Brackett Memorial Medal for 1928 was presented by Frank A. McInnes.

Executive Committee,
New England Water Works Association,
715 Tremont Temple,
Boston, Mass.

The Committee on the Award of the Dexter Brackett Memorial Medal for the year 1928 recommends that the medal be awarded to Francis W. Dean for his paper on "Pumping Station Practice," published in the June, 1928 issue of the Journal.

Respectfully submitted,

GORDON M. FAIR, *Chairman.*
FRANK A. McINNES,
G. E. LOURIE.

Frank A. McInnes. Mr. Dean, we are all proud, and jealous as well, of the reputation of the New England Water Works Association. We further realize that its reputation largely depends upon the quality of the papers prepared by our members to be read at the meetings and later to be published in the Journal. During the past year you contributed a paper entitled "Pumping Station Practice," which is a notable one and a valuable one,— exactly the sort of paper which we are proud to see on our permanent records.

I am sorry that the Chairman of the Committee on the Award of the Dexter Brackett Memorial Medal, of which I was a member, is not present, but I can say in his stead that we very carefully and conscientiously, and I was going to say prayerfully, considered a number of different papers,

and unanimously came to the decision that there was no question that the award rightfully and properly belongs to you.

I therefore, in the name of the Association, take very great pleasure in handing you the Dexter Brackett Memorial Medal. (*Presenting Medal to Mr. Dean, amid applause.*)

Closing of Polls and Appointment of Tellers.

The President. At this time it is necessary that we close the polls, and I appoint Harry W. Dotten of Winchester, Joseph E. Conley of Norwood, and John P. Miller of North Adams as a committee of tellers.

Proposal for Honorary Membership.

Samuel E. Killam. Mr. President, I should like to read the following communication.

To the Executive Committee
of the New England Water Works Association.
Gentlemen:

We, the undersigned, in accordance with Section 1 of Article III of the Constitution of the New England Water Works Association, are pleased to present the name of Sir Alexander Houston for Honorary Membership in this Association.

Sir Alexander Houston has for many years been in charge of water examination work for the London Metropolitan Water District and his contributions to the water works profession make him a worthy nominee for Honorary Membership in our Association.

Respectfully,

SAMUEL E. KILLAM,
FRANK A. BARBOUR,
CHARLES W. SHERMAN,
ROBERT SPURR WESTON,
FREDERIC H. FAY,
WILLIAM W. BRUSH,
HENRY ROBINSON BUCK,
ELBERT E. LOCHRIDGE,
STEPHEN DeM. GAGE,
GEORGE H. ABBOTT.

The President. No action has to be taken on this communication as it is a matter to be handled by the Executive Committee.

Committee Reports.

Progress reports were made by W. R. Conard (1) for the Committee on Standardization of Pipe Flanges and Fittings, (2) for the Sponsors for the Sectional Committee on Standardization of Cast-Iron Pipe and Special Castings and (3) for the Committee on Simplification of Manhole Frames and Covers. (See pages 347–350.)

Charles W. Mowry, representative of the Association on the A. S. A. Sectional Committees for (1) Specifications for Cast-Iron Pipe and Special

Castings and (2) Wrought-Iron and Wrought-Steel Pipe and Tubing submitted progress reports. (See pages 351 and 353.) He also made a progress report for the Committee on Standard Specifications, appointed by the President to act as a coördinating body for the various committees on specifications. (See page 354.)

A progress report of the Committee on the Collection and Correlation of Information Concerning the Corrosion of Iron and Steel Pipes and Standpipes was presented by Caleb M. Saville, Chairman of the Committee. (See page 358.)

After the close of the morning session the Convention party went by automobile to the new shops of the Portland Water District, where a Maine Clam Chowder Luncheon was served. This luncheon was prepared and served by the employees of the Portland Water District. After an inspection of the shops, the party proceeded to an inspection of the new Dunstan Standpipe, and the painting on the inside with M. B. Main hot coating. An inspection was also made of the Munjoy Standpipe, which had been painted with Main hot coating in 1919 and 1927.

Afternoon Session.

A progress report of the Committee on the Thawing of Frozen Water Hydrants was made by Percy R. Sanders.

A paper, "A Description of the System of the Portland Water District," was read by James W. Graham, Treasurer and General Manager of the Portland Water District.

Mr. David E. Moulton, Clerk and Attorney of the Portland Water District, gave a History of the Organization of the Portland Water District.

A paper on "Beauty in Water Works Structures" was read by John Calvin Stevens, Architect.

Evening Session.

(Robert Spurr Weston in the Chair.)

A paper on "Color Reduction in Storage Reservoirs" was read by Caleb Mills Saville, Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn. Karl R. Kennison, Robert Spurr Weston and Earl C. Craig took part in the discussion.

WEDNESDAY, SEPTEMBER 18.

Morning Session.

(President Arthur D. Weston in the Chair.)

A paper on "A Year's Experience with Automatic Chlorination at Concord, N. H.," was read by Percy R. Sanders, Superintendent of Water Works, Concord, N. H. Charles W. Mowry, C. P. Moat, S. H. MacKenzie and J. W. Graham took part in the discussion.

A paper on "The Water Service as a Business Enterprise" was read by Honorable Ralph S. Bauer, Mayor of Lynn, Mass. Honorable W. F. Sullivan, Mayor of Nashua, N. H., discussed Mr. Bauer's paper.

President Arthur D. Weston and Mr. David A. Heffernan brought up matters of particular interest to superintendents.

At the close of the morning session the Convention party left the hotel and took a steamer for a sail down Casco Bay, stopping at Long Island for a Clam Bake. This trip was made through the courtesy of the Water Works Manufacturers' Association, Inc.

Evening Session.

(*President Arthur D. Weston in the Chair.*)

Mr. George A. King, Massachusetts Member of the Legislative Committee, submitted a progress report of the Legislative Committee. (See page 356.) A general discussion followed in which the following took part: Arthur D. Weston, S. S. Anthony, David E. Moulton, Stephen H. Taylor and John F. Sullivan.

Mr. A. O. Doane, Chairman, submitted a progress report of the Committee on Painting Standpipes.

The report was discussed by: J. W. Graham, John F. Sullivan, Henry T. Gidley, S. H. MacKenzie, M. B. Main and Arthur D. Weston.

A paper on "Test of Large Meters in the Field" was read by R. E. Ferguson, Assistant Superintendent, Hersey Manufacturing Co., Boston, Roger W. Esty, A. D. Couch and L. C. Hough took part in the discussion.

A paper on "Experience with Diesel Engines in Water Works Plants" was read by A. D. Couch, Mechanical Engineer, Community Water Service Company, New York City. The paper was discussed by M. J. Reed and P. S. Wilson.

A paper on "Diesel Pumping Units at Wayland and Wilmington, Mass.," was read by J. Howard Hayes of the Hayes Pump and Machinery Company, Boston.

A general discussion regarding the general subject of Diesel engines as opposed to electrical and other power in the operation of water-works plants was entered into by Joseph W. Wattles, S. G. Wylie, H. A. Hanscom, Owen J. Eagan, Karl R. Kennison, Henry T. Gidley, Walter P. Schwabe, Stephen H. Taylor, Earl C. Craig, and Samuel A. Agnew.

THURSDAY, SEPTEMBER 19.

Morning Session.

A paper on "Method of Testing Cast Iron Pipe" was read by William R. Conard, of Conard & Buzby, Burlington, N. J. Stephen H. Taylor, E. E. Lockridge, H. A. Lacount, A. O. Doane, H. A. Hoffer, William F. Sullivan, E. W. Hermann, and J. W. Ledoux took part in the discussion.

A paper on "Some Uses of Aëration in Water Purification" was read by Malcolm Pirnie, Consulting Engineer, New York City. Robert Spurr Weston discussed this paper.

E. E. Lochridge, Chief Engineer, Springfield Water Works, Springfield, Mass., described the changes in the water works of the city of Springfield.

Afternoon Session.

The Secretary announced the election to membership by the Executive Committee of the following:

Members — Cecil C. Getchell, Bristol, R. I.; Myron G. Mansfield, Pittsburgh, Pa.; Martin E. Flentje, Harrisburg, Pa.; Earl W. Kelly, Duluth, Minn.; Harry F. Huy, Buffalo, N. Y.; William Plattner, Brattleboro, Vt.; Harrison P. Eddy, Jr., Boston; Daniel M. Ryan, Brockton, Mass.; Paul F. Kingman, Brockton, Mass.; Augustine A. Higgins, Brockton, Mass.; Richard Dillon, Hartford, Conn.; George A. Dickel, Roxborough, Pa.; Earle A. Tarr, Winthrop, Me.; Fred E. Smith, Cambridge, Mass.

Associates — Bingham & Taylor Corp., Buffalo, N. Y., and The Atlas Mineral Products Co. of Pa., Mertztown, Pa.

A paper on "The Reconstruction of the Pumping Station of the Western New York Water Company at Buffalo in Connection with the Construction of a 20,000,000 Gallon Filter Plant" was read by H. W. Huy, General Manager, Western New York Water Company. James M. Caird and J. W. Ledoux took part in the discussion.

A paper on "Making of Water Flow and Pressure Studies by the Water Works Engineer" was read by Hubert B. Smith of the Simplex Valve and Meter Company, Philadelphia, Pa. The discussion was participated in by H. W. Huy, Warren J. Scott, William A. MacKenzie, S. E. Killam, J. W. Ledoux, David A. Heffernan, John T. Robertson and George H. Finneran.

Evening.

By the courtesy of the Water Works Manufacturers' Association, Inc., a dinner dance was given at the Hotel Eastland to members and guests.

FRIDAY, SEPTEMBER 20.

(*Morning Session.*)

(*Robert Spurr Weston in the Chair.*)

A paper on "Watching the Weather in Safeguarding Public Water Supplies" was read by Arthur E. Gorman, Sanitary Engineer, Wallace & Tiernan Company, Newark, N. J. Warren J. Scott discussed the paper.

A paper entitled "Enforcement with Other Beverages" was read by J. Frederick Jackson, Consulting Engineer, New Haven, Conn. Warren J. Scott, William A. MacKenzie and Arthur D. Weston took part in the discussion.

(President Arthur D. Weston in the Chair.)

Report of Tellers of Election.

Total ballots cast	314
President.	
Robert Spurr Weston	312
Blank	2
Vice-President.	
George C. Brehm	303
Blank	11
Directors.	
E. Sherman Chase	308
Blank	6
R. A. Cairns	293
Blank	21
Treasurer.	
Albert L. Sawyer	305
Blank	9

(*Signed*) HARRY W. DOTTEN, *Chairman.*
JOSEPH E. CONLEY,
JOHN P. MILLER.

The President. You have heard the report of the tellers, and it is my pleasure to announce that you have elected Mr. Robert Spurr Weston, President, and Mr. Brehm, Vice-President, Mr. Cairns and Mr. Chase, Directors, and Mr. Sawyer, Treasurer of the Association.

The President read his address by title. (See page 328.)

The President. I now take pleasure in introducing your new President. Mr. Robert Spurr Weston. (*Great applause.*)

Robert Spurr Weston. No one who has belonged to this Association for thirty years fails to realize what an honor it is to be elected president, and no one who has had that length of membership fails to realize what a fine body of responsible men constitute it. Assuming the office as I do, I realize not only the honor but the responsibility of it.

The beginning of a term of office is no time to make promises or to predict or advise a course of action of an Association. I realize the duties as well as the honors, but with the help of our able Secretary and the officers whom you have elected, and of all of you, I trust that we shall have a successful year. I realize the long list of past presidents who have served you, not forgetting our hard working and able immediate Past President. I can only promise to do my best and give what I can, with the hope that at the end of my term of office I shall have more friends among the membership than I have now, and that you will like me better as I turn over the gavel to my successor. I thank you. (*Great applause.*)

Has the Secretary any business to come before the meeting?

Resolutions of Thanks.

Secretary Gifford. I have some resolutions which I would like to present, Mr. President:

The members of the New England Water Works Association and their guests attending the Forty-eighth Annual Convention have spent a most enjoyable four days in the city of Portland. Some controversial subjects may have been discussed at the technical sessions but there has been perfect agreement that the Association has never been better entertained.

This Association, therefore, resolves that a most hearty vote of thanks be extended to the Portland Water District and its employees, to the Portland Chamber of Commerce, to George F. West & Son, and to the Water Works Manufacturers' Association, for their cordial reception and most generous and courteous entertainment, all of which will be long remembered.

I present this statement as a resolution.

Arthur D. Weston. I second the motion for the adoption of this resolution. In doing so I want to express my own personal appreciation of the wonderful work done by the Portland committee. I do not think that we could have had anywhere near so much success had it not been for the untiring efforts of such men as Mr. Graham and Mr. Moulton. A great many members have expressed their appreciation in person.

The President. It is hardly proper for a chairman of a meeting to give his opinion regarding a resolution, but my heart is full of appreciation of the work of the local committee and of the friendly atmosphere of the city of Portland.

(*The resolution is unanimously carried by a rising vote.*)

(*Adjourned.*)

President's Address.

Some Legal Aspects of the Financial Management of Water Works in Massachusetts.

BY ARTHUR D. WESTON.*

In the State of Massachusetts the managing power of a municipally-owned water-works plant has always been regulated by an enabling act and left to an elective group of citizens known as the Board of Water Commissioners. The following excerpts from a few of these acts show that they were designed to prevent political interference, so far as practicable. Generally they provided for the election of the Commissioners for periods of several years with terms of office so overlapping that the board was not particularly affected by a political change in the municipality. The policy of organizing water departments in this manner has proved to be a sound one as evidenced by the success with which most water-works plants have been operated.

Chapter 190, Acts of 1865. Water Supply for the Town of Adams.

Section 3. Three commissioners shall be chosen by the said fire district by ballot, who shall, during their continuance in office, execute, superintend and direct the performance and execution of *all the works, matters and things* mentioned in the preceding sections, that are not specially otherwise provided for in this act; and they shall be subject to such rules and regulations, in the execution of their said trust, as the said district may, from time to time, ordain . . . . They shall respectively hold their said offices for the term of three years next after their appointment . . . .

Chapter 188, Acts of 1872. Water Supply of Concord and Lincoln.

Section 5. The treasurer of said town and the chairman of the selectmen, ex officiis, and three persons to be elected by ballot by the said inhabitants, as hereinafter provided, shall form a board of water commissioners, who shall *execute, superintend and direct the performance of all the works, matters and things* mentioned in this act, and exercise all the rights, powers and privileges hereby granted, and not otherwise specifically provided for herein, subject to the vote of said town.

Chapter 439, Acts of 1887. Andover.

Section 10. The said town shall, after its acceptance of this act, at a legal meeting called for the purpose, elect by ballot three persons to hold office, one until the expiration of three years, one until the expiration of two years and one until the expiration of one year from the next succeeding annual town meeting, to constitute a board of water commissioners . . . . *All the authority granted* to the said town by this act and not otherwise specifically provided for *shall be vested in said board of water commissioners,* who shall be subject, however, to such instructions, rules and regulations as said town may impose by its vote. The said commissioners shall be *trustees* of the sinking fund herein provided for . . . .

*Associate Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

Chapter 131, Acts of 1907. Bedford.

Section 9. . . . *All the authority granted to said town* by this act and not otherwise specifically provided for *shall be vested in said board of water commissioners*, who shall be subject however to such instructions, rules and regulations as the town may impose by its vote. A majority of said commissioners shall constitute a quorum for the transaction of business. Any vacancy occurring in said board from any cause may be filled for the remainder of the unexpired term by the town at any town meeting called for the purpose.

Chapter 456, Acts of 1908. Ashland.

Section 8. Said town shall, after its acceptance of this act, at the same meeting, or at a subsequent meeting duly called for the purpose, elect by ballot three persons to hold office, one until the expiration of three years, one until the expiration of two years and one until the expiration of one year from the next succeeding annual town meeting, to constitute a board of water commissioners; and at each annual town meeting thereafter one such commissioner shall be elected by ballot for the term of three years . . . .

Section 9. Said commissioners *shall fix just and equitable prices and rates* for the use of water, and shall prescribe the time and manner of payment. *The income of the water works shall be applied to defraying all operating expenses, interest charges and payments on the principal, as they accrue, of any bonds, notes or scrip issued under authority of this act. If there should be a net surplus remaining after providing for the aforesaid charges, it shall be used for such new construction as the water commissioners may determine upon and in case a surplus should remain after payment for such new construction, the water rates shall be reduced proportionately.* No money shall be expended in new construction by the water commissioners except from the net surplus aforesaid, unless the town appropriates and provides money therefor. Said commissioners shall annually, and as often as the town may require, render a report upon the condition of the works under their charge, and an account of their doings, including an account of receipts and expenditures.

Chapter 254, Acts of 1914. Somerset.

Section 10. . . . All the authority granted to the said town by this act and not otherwise specifically provided for shall be vested in said water commissioners, who shall be subject however to such instructions, rules and regulations as the town may impose by its vote . . . .

Section 11. Said commissioners shall fix just and equitable prices and rates for the use of water, and shall prescribe the time and manner of payment. *The income of the water works shall be applied to defraying all operating expenses, interest charges and payments on the principal as they accrue upon any bonds or notes issued under authority of this act. If there should be a net surplus remaining after providing for the aforesaid charges it shall be used for such new construction as the water commissioners may determine upon, and in case a surplus should remain after payment for such new construction the water rates shall be reduced proportionately.* No money shall be expended in new construction by the water commissioners except from the net surplus aforesaid, unless the town appropriates and provides money therefor. Said commissioners shall annually, and as often as the town may require, render a report upon the condition of the works under their charge, and an account of their doings, including an account of receipts and expenditures.

Chapter 276, Acts of 1926. Wilmington.

Section 8. . . . All the authority granted to the town by this act, except sections five and six and except as otherwise specially provided, shall be vested in said board of water commissioners, who shall be subject however to such instructions, rules and regulations as said town may impose by its vote . . . .

Section 9. Said commissioners shall fix just and equitable prices and rates for the use of water, and shall prescribe the time and manner of payment. *The income of the water works shall be applied to defraying all operating expenses, interest charges and payments on the principal as they accrue upon any bonds or notes issued under authority of this act. If there should be a net surplus remaining after providing for the aforesaid charges it shall be used for such new construction as the water commissioners may determine upon, and in case a surplus should remain after payment for such new construction the water rates shall be reduced proportionately.* No money shall be expended in new construction by the water commissioners except from the net surplus aforesaid unless the town appropriates and provides money therefor. All authority vested in said commissioners by the foregoing provisions of this section and by section three shall be subject to the provisions of section eight. Said commissioners shall annually, and as often as the town may require, render a report upon the condition of the works under their charge and an account of their doings, including an account of receipts and expenditures.

While the power of the Board of Water Commissioners as provided in the enabling acts that have been quoted is probably sufficient to secure proper financial control, much of this power has been removed by Chapter 396 of the Acts of the year 1928, for under this act the incurring of liabilities by any Board of Water Commissioners is limited to appropriations made by the municipality. Chapter 396 of those acts reads as follows:

An Act Relative to the Incurring of Liabilities and Indebtedness by Certain Cities and Towns.

Section 1. Section two of chapter forty-four of the General Laws is hereby amended by inserting after the word "act" the first time it appears in the eighth line the words:— which has or shall become effective after January first, nineteen hundred and twenty-one — so as to read as follows: — Section 2. Except in Boston and except as otherwise expressly permitted by law, cities and towns shall incur debts only in the manner of voting and within the limitations as to amount and time of payment prescribed in this chapter; but this section shall not be construed as prohibiting any city, town or district from placing additional restrictions, consistent with this chapter, upon the manner of incurring debt, nor as affecting the right of any city, town or district to incur debt under any special act which has or shall become effective after January first, nineteen hundred and twenty-one; but no debt may be authorized under a special act except by a two thirds vote, unless the act so provides.

Section 2. All provisions of special acts effective prior to January first, nineteen hundred and twenty-one which authorize the incurring of liabilities by any board or officer of a city, except Boston, or of a town without appropriation, or which authorize any such city or town to incur indebtedness for any purpose not permitted by general law, or which authorize any such city or town to incur indebtedness outside the statutory limit of indebtedness for a purpose

for which the incurring of indebtedness is provided by general law to be inside said limit, or which authorize the payment of debt by such a city or town in a manner inconsistent with general law, are hereby repealed. Nothing in this act shall be construed as affecting the validity of any act done prior to the effective date of this act in conformity with any special act, or the legality of any debt incurred, or of any bond or note issued, prior to said effective date, in accordance with any special act, or as affecting the liability of the obligor city or town to discharge any such debt, or its liability to pay the principal and interest on any such bond or note.

Section 3. This act shall take effect on January first, nineteen hundred and twenty-nine.

This act received but little attention from those interested in water-works management; consequently, no opposition to its enactment was presented to the Legislature. This apparent neglect was probably due to the fact that water department officials and other interested parties had not been advised of the pending legislation and its probable effect upon the operation of their departments. After passage of this act, furthermore, many water-works officials were confused as to its meaning.

One water department secured the following interpretation from its attorneys.

". . . 'Acts 1928, Chap. 396, sec. 2 (in effect January 1, 1929) provides in part:

'All provisions of special acts effective prior to January 1, 1921, which authorized the incurring of liabilities by any board or officer of . . . a town without appropriation, . . . are hereby repealed.'

An examination of these and other acts relating to your water system shows that, up to date effective of said 1928 Act, subject to the provisions as to new construction, the water board could incur liabilities which the town was bound to pay. The 1928 Act, however, expressly and broadly repeals the provisions of all special acts effective prior to January 1, 1921, which authorized the 'incurring of liabilities' by 'any board of a town without appropriation.' It makes no exceptions for Water Acts or Water Boards. It, therefore, applies to your case . . . ."

Within a comparatively short time after passage of this act some municipal officials realized the possibilities of using revenue obtained from the water department for other than water supply purposes. The selectmen of one town used the surplus accumulated by the water department for the construction of a schoolhouse, and in another the water department revenue was used for general municipal purposes, while bonds were issued to defray the financing of certain parts of the water-works plant. Such practices will inevitably result in rapid depreciation of the water-works plant and the expenditure of large sums for new equipment, all at the expense of the water consumers. This danger was realized by the "Special Commission Established to Investigate Municipal Expenditures and Undertakings and the Appropriation of Money Under Municipal Authority" as established by the 1928 session of the Massachusetts Legislature from whose report the following is quoted.

"Municipal water plants are operated in a large number of our cities and towns, and, while this service is looked upon as an enterprise or one that should be self-supporting, we find that practically every plant is established under authority of a special legislative act; and there does not appear to be any uniformity as to the provisions of these special acts, except in those recently establishing water systems. It is our opinion that, at the very beginning of the operation of municipal water supply systems, the rates should be such as will meet all the obligations. It must be admitted that the installation of such a system not only adds to the convenience and comfort of the inhabitants of a municipality, but materially enhances the value of their property, and while in towns it may not be practicable to give every one service at the outset, yet every one in the community benefits by reason of the increase in property value, which is subjected to a tax for all municipal purposes. Therefore a small amount levied as a direct tax to meet maturing debt charges might seem warranted during the first ten years after the installation of a water system; beyond this, however, the rates should be so fixed that they will be adequate to meet all annually recurring charges, together with debt and interest charges. *No portion of water revenue other than what would be a reasonable allowance for taxes, based upon what would be paid if the plant were privately owned, should be turned into the general treasury.*

The municipality should pay for water used for municipal purposes, the same as any other water taker; payment should also be made for hydrant rental, since for this service much larger mains and a greater supply of water must be provided than would otherwise be required for purely home consumption. The water taker should not either be unduly benefited or be penalized at the expense of the non-taker, or by a service for the benefit of all to which only a limited number contribute to its cost. Water revenue should be held entirely for water supply purposes, except as heretofore provided.

The need of some general provisions relative to the revenue of water plants is apparent, for today we have, in some communities, a direct tax to meet all the debt charges, and water revenue is used entirely for the maintenance of the plant; in other municipalities we find that water revenue is used the same as other departmental revenue to reduce the tax rate, with the result that, should there arise the need to replace mains or make extensions, sufficient money, in many cases, is not available, and a loan has to be resorted to; and this is somewhat of a temptation, since a loan for water purposes is outside the debt limit and is likely to unnecessarily increase the debt. In fact, when water revenue is used to reduce the tax rate, and borrowing is made for water mains replacement which could have been met from water revenue had it been reserved for water purposes, the same result is produced as when borrowing is made for ordinary departmental charges. If water revenue is held to be appropriated for water department purposes only, there can be no doubt but that the plant will be maintained on a more efficient basis."

It will be noted that in the report of the Commission as above quoted it is recommended that "no portion of the water revenue other than what would be a reasonable allowance for taxes, based on what would be paid if the plant were privately owned, should be turned into the general treasury." There is some question as to the wisdom of following such a recommendation unless careful consideration is given to the value rendered the municipality by the water department.

The report of this Commission recognizes the general value to the municipality of the installation of water works regardless of whether or not water is available to all the inhabitants, and it has been generally recognized that a large part of the total cost of the plant is for works necessary to provide adequate fire protection. The late Freeman C. Coffin of this Association once stated that the average increase in the construction cost of water works to provide fire protection is about 75 per cent., while the increase in the total annual maintenance charges is about 50 to 75 per cent. Mr. Coffin in his discussion of Emil Kuichling's paper "The Financial Management of Water Works," published in the *Transactions of the American Society of Civil Engineers* in December, 1897, states as follows: "Especially satisfactory is the strong position that the author takes in opposition to the endeavor to make a profit from the operation of the works or to the practice, which is sometimes advocated, of charging the expenses of some other department of municipal service to the maintenance account of the water department . . . . There is a general benefit to the community derived from schools and sewers besides that accruing to the individual. This is true, and it may well be that this general benefit far outweighs the aggregate of the particular benefits, and thus obliterates any injustice that is caused by the inequality of the amount of service rendered the individual. If this is true of such agencies, it is no less sure of a suitable supply of water for domestic, manufacturing and fire purposes. An extremely strong case can be made for the supplying of water free, and meeting the maintenance account from the general taxes. The strong and valid objection to this course is that it would deprive the department of the only available and effective weapon of defence against waste of water . . . ." In his paper entitled "The Financial Management of Water Works" read before the New England Water Works Association, June 10, 1896, Mr. Coffin states:

"As the benefits arising from this fire protection inure to the taxpayers and not to the water consumers, it is only just that at least the additional expense caused by it should be borne by the former. . . ."

How the water department should be compensated for this service is not a matter under discussion in this paper, and the author does not pretend to recommend any one method. Each has its merits, whether it be a lump sum tax, hydrant rental or payment on the inch-foot basis. Each should be based on the general principle that adequate fire protection will be provided.

An examination of the returns from 36 water companies in Massachusetts made to the Department of Public Utilities in the year 1929 shows that the assessed valuation of the works as made by the assessors varies from 24 per cent. to 112 per cent. of the book value of these works, while the total assessed valuation of all those reporting was about 60 per cent. of the total book value of these plants. This figure is somewhat lower than that of

75 per cent. which has generally been considered as giving the relation of the average assessed valuation to the actual value of real estate taxed in most municipalities.

Still another examination shows that in 39 municipalities where the water is pumped the annual maintenance charges varied from 0.90 to 12.16 per cent. of the given values of the plants, while the total annual maintenance charges were 1.99 per cent. of the total given values of the plants.

Using the formula of Metcalf, Kuichling and Hawley,* in which

$$Y = \frac{147}{X^{0.81}} - 12.1$$

equals the per cent. of the total cost of the works chargeable to fire protection and X equals the population in thousands, the following relations between the population of five typical municipalities, the value of the plant chargeable to fire protection, and the total costs of the works are obtained.

Municipality.	Total Cost of Works.	Population.	Percentage of Total Plant Cost Chargeable to Fire Protection.	Amount of Plant Value Chargeable to Fire Protection.
A	$228 929	4 229	84	$192 300
B	571 111	14 178	54	308 400
C	1 204 706	16 164	51	614 400
D	1 590 121	55 251	31	492 900
E	2 095 862	62 354	29	607 800
F	3 525 493	81 643	25	881 400

Considering these charges for fire protection and the percentage of the total annual charges for maintenance we have the following:

Municipality.	Percentage of Maintenance to Total Cost of Works.	Amount of Plant Value Chargeable to Fire Protection.	Maintenance Chargeable to Fire Protection.
A	1.97	$192 300	$3 788
B	2.21	308 400	6 816
C	1.49	614 400	9 155
D	1.96	492 900	9 661
E	1.85	607 800	11 244
F	1.51	881 400	13 309

Taking now the value of the works chargeable to fire protection which must be met by the retirement of bonds and the interest on the bonds, together with the amounts chargeable to maintenance, we have the following:

Engineering News, Vol. 65, No. 24, 1911.

ANNUAL YEARLY CHARGES
CHARGEABLE TO FIRE PROTECTION.

Municipality.	Charges for Bond Retirement (30 Yr. Bonds).	Interest on Bonded Debt* (4 per cent.).	Maintenance.	Total Annual Charges.
A	$6 410	$3 974	$3 788	$14 172
B	10 280	6 374	6 816	23 470
C	20 480	12 698	9 155	42 333
D	16 430	10 187	9 661	36 278
E	20 260	12 561	11 244	44 065
F	29 380	18 216	13 309	60 905

*Average for period.

No charge made for depreciation.

Using the above tables and assuming that the taxes are to be paid at the rate of $30 a thousand on 75 per cent. of the value of the plant, the following table is arranged to give a comparison between such a tax and the amount which is chargeable to the municipality for fire protection.

RELATION OF ANNUAL CHARGES FOR FIRE PROTECTION
TO PROBABLE TAX RETURN AT RATE OF $30 PER THOUSAND.

Municipality.	Amount of Annual Charges for Fire Protection.	75 per cent. of Valuation of Works.	Taxes Based on 75 per cent. of Valuation of Works at $30 per Thousand.	Excess of Annual Charges for Fire Protection over Tax Return.
A	$14 172	$171 697	$5 151	$9 021
B	23 470	428 333	12 850	10 620
C	42 333	903 530	27 106	15 227
D	36 278	1 192 591	35 778	500
E	44 065	1 571 897	47 157	−3 092
F	60 905	2 644 120	79 324	−18 419

These tables show rather conclusively that in the municipalities of less than 60 000 population a tax at the rate of $30 per thousand on 75 per cent. of the total value of the plant yields less return to the municipality than the actual value received from fire protection. In addition the municipality profits further by an increase in the property valuation resulting from the installation of the water-works plant. Quoting again from Freeman C. Coffin " . . . The benefit from a water supply to owners of land upon which there is no insurable property is also great. It is notorious that this class of property holders does not, as a rule, pay excessive taxes."

To sum up, Chapter 396 of the Acts of the year 1928 in its present condition on the statute books can rightfully be considered dangerous legislation. By this act the temptation is ever present to those in governing authority in a municipality to divert funds obtained from water revenue to other than water supply purposes. This practice must inevitably end

in the neglect of the water-works plant and may result in the pollution of the supply, loss of life among the consumers and the loss of large sums of money by the municipality in payment of damages resulting from suits.

It appears advisable, under the circumstances, that the General Laws affecting the financing of water departments be further amended so as to prevent the diversion of water-works funds for other than water supply purposes. Such an amendment does not, in the opinion of the author, need to provide for the payment to the municipality of a sum of money in lieu of taxes, as the municipality already receives considerable benefit from the water-works plant for which it contributes no return on the investment. The author suggests the following amendment to the General Laws.

THE COMMONWEALTH OF MASSACHUSETTS.

In The Year One Thousand Nine Hundred and Twenty Nine.

AN ACT REGULATING THE USE OF WATER DEPARTMENT REVENUE.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

Section 1. Chapter forty-four of the General Laws is hereby amended by adding the following new section:— *Section 2a.* All water department revenue shall be held and appropriated only for maintenance, operation and improvement of water works plants, for the retirement of water works bonds and for the payments of interest upon such bonds.

Section 2. This act shall take effect upon its passage.

Annual Report of the Secretary.

Mr. President and Gentlemen of the New England Water Works Association,— The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 830, constituted as follows: 14 Honorary, 701 Members, 0 Juniors, 13 Corporate Members and 102 Associates. The detailed changes are as follows:

MEMBERSHIP.

September 1, 1928.	Honorary Members		10		
	Elected:				
	February, 1929	4	4		14
September 1, 1928.	Total Members		689		
	Withdrawals:				
	Transferred to Honorary Members.	4			
	Resigned	7			
	Dropped	5			
	Died	12	28	661	
	Elected:				
	September, 1928	5			
	November, 1928	6			
	December, 1928	5			
	January, 1929	3			
	February, 1929	6			
	March, 1929	3			
	April, 1929	1			
	June, 1929	7	36		
	Junior transferred to Member	1	1		
	Reinstated:				
	Dropped in 1924–25	1			
	Dropped Jan. 1924 to Sept. 1924	1			
	Dropped in 1911	1	3	40	701
September 1, 1928.	Total Juniors		1		
	Transferred to Member		1		0
September 1, 1928.	Total Associates		98		
	Withdrawals:				
	Dropped	1	1	97	
	Elected:				
	January, 1929	1			
	February, 1929	2			
	March, 1929	2	5	5	102
September, 1 1928.	Total Corporates		11		

Elected:			
November, 1928	1		
June, 1929	1	2	13
September 1, 1929. Total Membership			830
September 1, 1928. Total Membership			809
Net gain			21

Members Elected from September 1, 1928, to September 1, 1929.

Honorary Members.

February 13, 1929. Transferred from Members: H. W. Clark, H. P. Eddy, F. A. McInnes, C. M. Saville. (4)

Members.

September 18 to 21, 1928. T. W. Dix, R. A. Harrington, J. C. Moore, J. W. Vaughan, C. R. Weagraff. (5)

November 14, 1928. J. J. Devlin, D. W. Foster, C. T. Gilliard, R. L. Reed, B. F. Snow, B. W. Vaughan. (6)

December 12, 1928. E. A. Ekern, J. A. Hancock, H. W. MacWilliams, J. V. Turner, W. E. Rundlett. (5)

January 9, 1929. S. A. Benson, P. C. Charnock, F. L. Flood. (3)

February 13, 1929. R. F. Comerford, L. A. Goodale, E. A. Gorman, Walter Knowles, R. G. Lingley, Lester Priest. (6)

March 13, 1929. H. B. Collins, A. V. Harrington, R. W. Macdonald. (3)

April 10, 1929. H. W. Griswold. (1)

June 18, 1929. Frank Becker, H. L. Clark, W. C. Conroy, H. E. Halpin, H. A. Nutting, W. A. Tucker, Jr., F. C. Williams. (7)

Reinstated:		
Dropped in 1911 (B. B. Hodgdon)	1	
Dropped, January, 1924 to September, 1924 (A. T. Clark)	1	
Dropped in 1924–1925 (J. E. Conley)	1	3

Junior.

Transferred to Member: Frederick O. A. Almquist. (1)

Associates.

January 9, 1929. Anthony Ross & Son. (1)

February 13, 1929. Walter Field & Son; Mansfield Foundry Company. (2)

March 13, 1929. Bennett Company, C. H. Tucker. (2)

Corporates.

November 14, 1928. Hudson (Mass.) Dept. Public Works. (1)

June 18, 1929. Falmouth (Mass.) Water Dept. (1)

Members.

Died: G. W. Batchelder, F. D. Berry, H. F. Bryant, R. N. Ellis, F. B. Forbes, R. A. Hale, D. J. Howell, Walter Knowles, Thomas McKenzie, F. F. Moore, D. A. Reed, R. J. Harding. (12)

Resigned: John Brown, T. J. Hersom, Jr., Scott Keith, F. T. Kemble, F. N. Speller, A. E. Walden, E. E. Wall. (7)

Dropped: C. E. Drake, C. R. McFarland, Hugh Nawn, P. S. Nugent, A. L. Gammage. (5)

Associates.

Dropped: Van Gilder Water Meter Company. (1)

Receipts for Fiscal Year, September 1, 1928, to September 1, 1929.

Entrance Fees			$174.00
Annual Dues:			
Members	$3 852.75		
Corporates	120.00		
Associates	1 860.00	$5 832.75	
Fractional Dues:			
Members	$75.00		
Associates	55.00	130.00	
Past Dues:			
Members	$40.00		
Associates	20.00	60.00	
1929–1930		17.50	
Total Dues			6 040.25
Advertisements			4 116.00
Subscriptions			547.00
JOURNALS sold			144.24
Sundries			948.85
Total			$11 970.34
There is due the Association:			
Advertisements		$90.00	
Subscriptions		76.00	
Reprints		5.60	171.60
Total			$12 141.94

Respectfully submitted,

FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer.

September 1, 1928, to August 31, 1929.

The President and Members of the New England Water Works Association:

I herewith submit my report as treasurer for the year ending August 31, 1929.

Receipts.

September 1, 1928 — Cash on hand			$1 087.84
Initiation fees	$174.00		
Dues	6 040.25	$6 214.25	
Interest and dividends			787.91
Journal:			
Advertisements	$4 116.00		
Sale of Journals	144.24		
Sale of reprints	76.05		
Subscriptions	547.00	4 883.29	
Miscellaneous:			
Certificates of membership	$13.50		
Filtration forms	6.60		
Membership lists	7.50		
Meter sheets	1.00		
Sale of cuts	20.35		
Standard specifications	3.75		
Refund Pawtucket	19.95		
Surplus dinner tickets	12.00		
Sundries	.24	84.89	
Total receipts			11 970.34
			$13 058.18

Expenditures.

Journal:			
Advertising agent's salary and commission	$180.00		
Editor's salary	500.00		
Editor's expense	26.67		
Plates	298.59		
Printing	4 534.45		
Reporting	552.43		
Reprints	531.08		
Stationery and postage	117.65	$6 740.87	
Office:			
Affiliated Technical Societies	$2 160.00		
Certificates of membership	16.00		
Exchange	3.00		
Printing, stationery and postage	177.14		
Secretary's salary	400.00		
Secretary's expense	327.14		
Treasurer's salary, bond, etc.	112.50		
Sundries	34.65	3 230.43	

Meetings and Committees:			
Badges	$181.28		
Dinners for guests	67.65		
Printing, stationery and postage	546.52		
Stereopticon	112.20		
Committee on cement-lined pipe	247.98		
Committee on pipe, share of expense	400.00		
Committee on corrosion	61.85		
Sundries	40.21	$1 657.69	
Total expenditures			$11 628.99
August 31, 1929 — Cash on hand			1 429.19
			$13 058.18

Invested Funds.

Invested funds September 1, 1928		$15 622.43
Interest on bonds	$80.00	
Interest on deposits	51.63	
Interest on savings bank deposits	656.28	787.91
		$16 410.34
Interest paid over to the Association		$787.91
Invested funds August 31, 1929		15 622.43
		$16 410.34

The Finance Committee for the fiscal year ending August 31, 1929 recommended a budget of $11 400 and later at the March meeting of the Association an additional sum of $400 was voted, making the total budget $11 800.

There has been expended during the year $11 628.99, leaving an unexpended balance of $171.01. The details are as follows:

	Journal.	Office.	Meetings.
Appropriation	$7 000.00	$3 400.00	$1 400.00
Transferred from	257.69	.....	.....
	$6 742.31	$3 400.00	$1 400.00
Transferred to	.....	.....	257.69
	$6 742.31	$3 400.00	$1 657.69
Expended	6 740.87	3 230.43	1 657.69
	$1.44	$169.57	.....

Respectfully submitted,

ALBERT L. SAWYER, *Treasurer.*

TREASURER'S REPORT.

Statement of Receipts and Expenditures.

Receipts.		*Expenditures.*	
Cash on hand — September 1, 1928	$1 087.84	Bills paid as per vouchers	$11 628.99
Interest on bonds and deposits	787.91	Cash on hand — August 31, 1929	1 429.19
Received from Secretary	11 182.43		
	$13 058.18		$13 058.18

Assets and Liabilities.

Assets.			*Liabilities.*	
Cash in banks as per list		$15 236.62	Surplus	$17 223.22
Old Colony Trust Co.	$1 429.19			
City Five Cents Savings Bank	2 000.00			
Farmers and Mechanics Savings Bank, Framingham	2 068.46			
Franklin Savings Bank	2 000.00			
Haverhill Savings Bank	2 000.00			
Home Savings Bank	1 011.25			
Mechanics Savings Bank	1 261.19			
Pentucket Savings Bank	2 000.00			
Peoples Savings Bank	1 466.53			
Bonds Nos. 2642 and 2644 Lake Shore & Michigan So. R.R. 4's due May 1, 1931		1 815.00		
Accounts Receivable		171.60		
Advertisements	$90.00			
Subscriptions	76.00			
Reprints	5.60			
		$17 223.22		$17 223.22

Annual Report of the Editor.

To the New England Water Works Association: The Editor submits herewith the following report for the year ending August 31, 1929.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed.

Table 1 is a statement of the material published.

Table 2 gives the receipts and expenditures for the year.

Table 3 is a comparison of the Journal for the past year with preceding years.

Size. The four issues contained 745 pages, of which 507 were text.

Cost. The gross cost of the Journal was $6 740.87 equivalent to $6.17 per member, and, the net cost was $1 857.58 equivalent to $1.70 per member.

Reprints. Fifty reprints of each paper have been furnished to the author where desired.

Circulation. The present circulation of the Journal is:

Members, all grades	831
Subscribers	147
Exchanges	15
Total	993

(Journals *have been sent to all subscribers.*)

Respectfully submitted,

GORDON M. FAIR, *Editor.*

EDITOR'S REPORT.

TABLE 1.

STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1928, AND MARCH AND JUNE, 1929, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Date.	Pages of.								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
September, 1928	121	3	124	0	50	5	0	179	37
December, 1928	98	48	146	7	50	5	4	212	82
March, 1929	75	37	112	0	53	5	1	171	34
June, 1929	111	14	125	0	53	5	0	183	33
Total	405	102	507	7	206	20	5	745	186

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF SEPTEMBER AND DECEMBER, 1928, AND MARCH AND JUNE, 1929, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Receipts.		*Expenditures.*	
Advertisements	$4 116.00	Reporting	$552.43
Subscriptions	547.00	Printing	4 534.45
Sale of JOURNALS	144.24	Plates	298.59
Sale of reprints	76.05	Mailing and postage	117.65
		Reprints	531.08
	$4 883.29	Editor's salary	500.00
Net cost of JOURNAL	$1 857.58	Editor's incidentals	26.67
		Advertising agent's salary and commissions	180.00
	$6 740.87		$6 740.87

EDITOR'S REPORT.

TABLE 3.

COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XXXIII. 1919.	Vol. XXXIV. 1920.	Vol. XXXV. 1921.	Vol. XXXVI. 1922.	Fiscal Year Ending Aug. 31, 1924. 4 issues.	Fiscal Year Ending Aug. 31, 1925. 4 issues.	Fiscal Year Ending Aug. 31, 1926. 4 issues.	Fiscal Year Ending Aug. 31, 1927. 4 issues.	Fiscal Year Ending Aug. 31, 1928. 4 issues.	Fiscal Year Ending Aug. 31, 1929. 4 issues.
Average edition (copies printed)	1 200	1 130	1 150	1 100	1 100	1 100	1 100	1 100	1 138	1 200
Average membership	902	885	864	826	764	755	775	784	808	831
Circulation at end of year	1 002	970	929	929	880	873	906	916	955	993
Pages of text	566	359	399	618	404	421	523	492	528	507
Pages of text per 1 000 members	627	406	462	748	529	558	675	628	654	610
Total pages, all kinds	726	520	560	801	611	644	761	724	769	745
Total pages per 1 000 members	805	588	648	970	800	853	982	952	952	896
GROSS COST:										
Total	$4 967.99	$5 011.03	$5 381.84	$6 354.10	$4 783.60	$5 272.91	$6 524.62	$5 839.36	$6 849.44	$6 740.87
Per page	6.84	9.64	9.61	7.93	7.83	8.19	8.57	8.07	8.91	9.06
Per member	5.51	5.66	6.23	7.69	6.26	6.98	8.42	7.45	8.48	8.12
Per member per 1 000 pages	7.59	10.88	11.12	9.60	10.25	10.84	11.07	10.29	11.02	9.77
Per member per 1 000 pages text	9.74	15.77	15.61	12.47	15.50	16.58	16.10	15.13	16.06	16.01
NET COST:										
Total	$2 675.04	$1 722.14	$1 869.85	$2 434.26	$561.51	$943.40	$2 040.28	$710.63	$1 716.25	$1 857.58
Per page	3.68	3.31	3.34	3.04	0.92	1.46	2.68	.98	2.23	2.07
Per member	2.97	1.95	2.16	2.95	0.74	1.25	2.64	.91	2.12	2.24
Per member per 1 000 pages	4.09	3.75	3.87	3.68	1.20	1.94	3.47	1.26	2.76	2.50
Per member per 1 000 pages text	5.25	5.43	5.43	4.77	1.82	2.97	5.05	1.85	4.02	4.41

Report of Finance Committee.

Executive Committee,
New England Water Works Association.

Gentlemen:

The Finance Committee has examined the books and accounts of the Secretary and the Treasurer for the fiscal year ending August 31, 1929 and finds them correct.

The Committee submits the following budget for the fiscal year ending August 31, 1930.

	Expended. 1928–1929.	Recommended. 1929–1930.
Journal	$6 740.87	$7 000
Office	3 230.43	3 200
Meetings and committees	1 657.69	1 800
Total	$11 628.99	$12 000

The amount to be paid to the Engineering Societies of Boston for dues and charges as a member society for the year ending May, 1930 is $2 160 which is the same as paid in the last fiscal year.

The Finance Committee last year recommended and the Association approved a budget of $11 400 and in March $400 additional was voted for use of the Cast-Iron Pipe Committee of the Sectional Committee of the American Standards Association of which this Association is one of the sponsor societies, making a total budget of $11 800. The Committee finds that there was expended during the year $11 628.99 leaving a balance of $171.01.

The Committee believes that the Sectional Committee will request additional funds to carry on their work and has included $400 in this budget.

The receipts for the fiscal year 1928–1929 amounted to $11 970.34 of which $787.91 was from interest and dividends from the Invested Funds of $16 410.34.

Respectfully submitted,

SAMUEL E. KILLAM,
H. P. BAUMS,
ARTHUR C. KING.

September 6, 1929.

PROGRESS REPORT OF THE COMMITTEE ON STANDARDIZATION OF PIPE FLANGES AND FITTINGS.

BY W. R. CONARD.*

Your representative on the Committee on Standardization of Pipe Flanges and Fittings can report progress as follows:

The Sub-Committee No. 1 on the Committee on Standard Pipe Flanges and Fittings held a meeting in Rochester, N. Y., May 17, 1929 with the following action:

Twenty-five Pound Cast Iron Standard. The Chairman, Mr. A. M. Houser, called attention to the proposed American Standard for 25-lb. Cast Iron Pipe Flanges and Flanged Fittings which had been approved by the Sectional Committee in June, 1928. Then, owing to a request from Sub-Committee No. 4 on Gas and Air Piping Systems of the Sectional Committee on the Code for Pressure Piping, the proposal was referred back to Sub-Committee No. 1 of the Sectional Committee on Pipe Flanges and Flanged Fittings for revision so as to satisfy the requirements of the American Gas Association and the American Water Works Association for low pressure piping. Changes in this proposal to make it acceptable to the A. G. A. and the A. W. W. A. have been completed and it was expected that revised proof sheets would be available at this meeting.

A general discussion followed during which it was stated that through the activity of the Sub-Group on Low Pressure Flanges and Flanged Fittings, of which Mr. H. A. Hoffer is Chairman, a large amount of work had been done. The Committee was reminded also of the tests now being made for body thickness at the University of Illinois under the direction of Sub-Committee No. 1 of the Sectional Committee on Cast Iron Pipe, known as A 21. In view of this apparent overlapping of activities, it was *Voted* that a Special Committee of Correlation be appointed to consist of representatives of the Sectional Committees B 16, A 21, and Sub-Committee No. 7 on Rating of Pipe Fittings to consider the flange data proposed at the October 24, 1928 meeting, together with the results of the tests now being conducted at the University of Illinois and to report its recommendations to Sectional Committee A 21 and B 16 for further action.

One Hundred Twenty-five Pound Cast Iron Standard. Mr. Hoffer raised the question of port openings and stated that numerous inquiries were being received in regard to this item in connection with the American Standard for 125-lb. Cast Iron Pipe Flanges and Flanged Fittings. It was decided that classification of this item was desirable and it was *Voted* that a column be included in the next revision of the American Standard for 125-lb. Cast Iron Pipe Flanges and Flanged Fittings similar to the column given in the

*Representative of the New England Water Works Association.

American Standard for 250-lb. Cast Iron Pipe Flanges and Flanged Fittings entitled "Diameters of Port," the dimensions of which shall be identical with those of the column entitled "Nominal Pipe Size" with the elimination of the letters "OD" on sizes 14 to 96 inches inclusive.

Eight Hundred Pound Cast Iron Standard. Mr. Darling reported the results of the letter ballot on the proposed American Standard for 800-lb. Hydraulic Cast Iron Pipe Flanges and Flanged Fittings and pointed out that the "Approved with reservations" votes concerned changes in sections dealing with "Materials," "Marking," and the status to be given the standard by the A. S. A.

Mr. Conard said that he had approved the proposed standard for consideration as "Tentative" pending the results of tests which he understood were being made by the Sectional Committee on the Standard of Cast Iron Pipe. It was pointed out, however, that the tests being made by that committee are being confined to lower pressure piping. He accordingly withdrew his conditional vote and approved the proposal for consideration as an "American Standard."

The conditional votes regarding the marking of this standard were next discussed and after due consideration of the recommendations received on the letter ballots and the proposal made by Sub-Committee No. 7 on Marking of Pipe Flanges and Flanged Fittings, it was *Voted* that the proposal be revised so that the pipe flanges and flanged fittings of this rating should be marked with the letters "C I" indicating cast iron and the letters W. O. G. denoting that they were to be used for Water, Oil or Gas service, in addition to the number "800" as previously specified.

The conditional votes regarding the paragraph on "Materials" were then reviewed and, it was *Voted* that the final approval of the proposed American Standard for 800-lb. Hydraulic Cast Iron Pipe Flanges and Flanged Fittings be withheld pending action by the A. S. T. M. on the proposed material specification on "Cast Iron for Flanges" which is to be submitted to that Society for approval at their June, 1929 meeting.

It was the sense of the meeting that if the material specification received formal approval by that Society, it should be incorporated in the proposed American Standard for 800-lb. Cast Iron Pipe Flanges and Flanged Fittings.

PROGRESS REPORT OF THE SPONSORS FOR THE SECTIONAL COMMITTEE ON STANDARDIZATION OF CAST IRON PIPE AND SPECIAL CASTINGS.

BY W. R. CONARD.*

As your representative on the Committee of the Sponsors for the Sectional Committee on Standardization of Cast Iron Pipe and Special Castings, I report:

That the Sectional Committee met in New York City, March 26, 1929 with Charles W. Sherman and W. R. Conard present representing the NEW ENGLAND WATER WORKS ASSOCIATION.

The Chairmen of the various Technical Committees reported progress for their various activities approximately as follows:

1. On Dimensions.

General progress was the most that this Technical Committee could report inasmuch as "Dimensions" to be presented depend upon the reports and recommendations of the other two Technical Committees as a basis for recommending changes from the standards now in use.

2. On Metallurgy, Processes and Tests.

This Committee presented considerable progress on tests being conducted on Physical Tests and Test Specimens, but asked for additional time to give final data and recommendations as well as data on the other work coming under their charge such as Raw Materials and Melting Practice; Metallurgy and Chemistry; Experience.

3. Corrosion and Protective Coatings.

This Committee reported considerable progress also, especially on Tar Coatings and Cement Linings, progress reports at previous meetings having been presented on The Theory of Corrosion; Water Corrosion Experience; Soil Corrosion.

The Sectional Committee now has an Executive Assistant to the Chairman and he is hard at work trying to correlate the reports and progress of the various Technical and Sub-Committees. The Annual Meeting to be held next year should see the work much further advanced.

*Representative of the New England Water Works Association.

PROGRESS REPORT OF THE COMMITTEE ON SIMPLIFICATION OF MANHOLE FRAMES AND COVERS.

BY W. R. CONARD.*

For the Committee on Manhole Frames and Covers, I report progress as follows:

The Sectional Committee is considering design of Standards as follows:

1. Size of opening in head.
2. Depth of head.
3. Size of head flange.
4. Thickness and strength of cover.
5. Shape and number of openings in cover.
6. Effect of character of paving on dimensions and shape of head.
7. Identification of purpose for which manhole is used.
8. Character of finish of seat and bearing face of cover.
9. Tolerances allowed in dimensions.
10. Facilities provided for removal of cover.
11. Facilities provided for bringing heads to grade.
12. Facilities provided for locking covers in place.
13. Dimensions to give required strength and durability.

The Sub-Committee of which I am a member is that for sewer, water, gas, steam and air manhole frames and covers. There appear to have been meetings of this Sub-Committee in May, 1926, January, 1928, April, 1928 and December, 1928, or if these were not actual meetings, there was correspondence discussing the matters which were coming before this Sub-Committee.

There appear to have been submitted for consideration in January, 1928, tables of dimensions and some sketches of suggested design and at the April, 1928 meeting, modifications were discussed. At the December meeting, which appears to have been by correspondence, the question of the finish of the seats of the frames and bearing face of the covers was discussed and requests for further discussion asked for.

Under date of February 2, 1929, the Chairman of this Sub-Committee asked for information relative to diameters of frames and covers larger than 30 in. which might be needed to be included within the scope of the Sub-Committee.

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*Representative of the New England Water Works Association.

PROGRESS REPORT OF THE COMMITTEE ON SPECIFICATIONS FOR CAST IRON PIPE AND SPECIAL CASTINGS.

BY C. W. MOWRY.*

As your representative on the A. S. A. Sectional Committee on Specifications for Cast Iron Pipe and Special Castings, I report as follows:

The work of the Committee has proceeded on a broad scale, being sub-divided among three technical committees and ten sub-committees.

Experimental work in the investigation of organic coatings for pipe is now going on at the plant of the American Cast Iron Pipe and Foundry Company, where facilities and the services of an engineer have been placed at the disposal of this Committee.

Plans have been made for a series of full size service exposure tests of cement lined cast iron pipe, and these will be carried out in the vicinity of the Birmingham Water Works Company.

A study of field failures of pipe obtained from the users of cast iron pipe in the water, gas, oil and petroleum industries has indicated that the remedy lies in taking greater precautions in handling, storing and maintaining the pipe, and that changes in the design or in the dimension of the pipe, or an increase in the strength of the metal are not necessary.

An extensive series of trench load tests is under way at Iowa State College. Definite information is expected on the question of earth load, which has been much discussed in the past, and regarding which little is actually known. Work is under way with 8-in. and 20-in. pipe to obtain knowledge of the stresses within the pipe in the ground under normal earth load, under heavy cover, and when the support under the pipe is poor.

At the University of Illinois, a careful study is being made of the strength of pipe. New methods of testing are greatly increasing the knowledge of the properties of cast iron pipe.

At the Massachusetts Institute of Technology tests are under way to determine the corrosion in water of cast iron pipe of various chemical composition, and with different coating materials.

All the test work is very carefully planned and supervised. Samples of pipe come from different foundries in all parts of the country and are of the ordinary run of pipe. Complete information with all details of manufacture is recorded for each test specimen.

The Sectional Committee is following closely the soil corrosion studies started by the U. S. Bureau of Standards in 1922. In this investigation 14 000 specimens were buried in forty-seven different types of soil. A certain number of specimens are removed at two-year intervals. The re-

*Representative of the New England Water Works Association.

sults of the examination of 2 000 of these specimens have been summarized and the following factors affecting corrosion are indicated:

Most soils have a low rate of corrosion. Those well drained and coarse-grained show less corrosion than those which are wet and of silty nature. The most corrosive soils are those with a high per cent. of sulphates (white alkali). The rate of corrosion appears to decrease with the time of the exposure. Bituminous coatings in general do not furnish sufficient protection against corrosive soil conditions.

The interest shown by the manufacturers of cast iron pipe in the investigation and research being carried on by the American Standards Association is very gratifying. On the first of March, 1929 funds totalling $57 731.08 had been made available by manufacturers' contributions. Of this amount, $18 750 has already been spent.

PROGRESS REPORT OF THE COMMITTEE ON WROUGHT IRON AND WROUGHT STEEL PIPE AND TUBING.

BY C. W. MOWRY.*

As your representative on the A. S. A. Sectional Committee on Wrought Iron and Wrought Steel Pipe and Tubing, I report as follows:

The ultimate aim of this Sectional Committee is to standardize the design, dimensions, and material requirements of all classes of wrought iron and steel pipe and tubing and all types of riveted pipe. With this end in view, it is the intent to pool all existing standards and specifications; and out of this pool to develop a minimum of standard specifications, applicable to as many industries as possible, without unnecessary duplication. The Committee appreciates the necessity of maintaining present outside dimensions of pipe in order to permit cutting the standard pipe threads.

The Committee personnel is divided into Sub-Committees, one on Pipe and Tubing for Low Temperature Service, another for High Temperature Service (above 450 degrees F.), and a third on Materials.

The Sub-Committees will frame basic formulas for the design of pipe and tubing and will prepare tentative schedules of dimensions to be presented to the Sectional Committee as a whole. Tentative standards for lap-welded and seamless steel pipe for ratings ranging from 250 to 1 350 lb. per square in. have already been submitted for letter ballot.

*Representative of the New England Water Works Association.

PROGRESS REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS.

BY C. W. MOWRY.*

I have been asked to report for the new committee on Standard Specifications, with any recommendations which we might care to make to the Executive Committee concerning the reports of the standing committees.

Since the report on the Standardization of Pipes and Fittings is merely a progress report we have no recommendations to make. Regarding the work of the Committee on Cast Iron Pipe and Special Castings, a progress report has also been presented. We have no recommendations to make regarding it. The same is true of the report on Manhole Frames and Covers. We have a report, however, from Mr. Howland on the Standardization of Screw Threads for Small Hose Couplings. Mr. Howland, as you know, is a member of the committee of the American Standards Association, which has surveyed all of the existing hose threads in the country,—for chemical hose, inside hose, standpipes, and small hose for outside use. This committee finds that hose threads, starting from ½ in. and going up to 2 in., have a great variety of threads, and that there is also a duplication of hose threads. For example, 1½-in. inside hose has 11½ threads, whereas 1½ outside hose has 9 threads per in. There is furthermore a difference on the 2-in. hose when used inside and outside.

Our committee, after reviewing the situation, is prepared to recommend to our Executive Committee that it suggest to Mr. Howland the possibility of eliminating the pipe thread entirely for the hose for inside use and adopt the coarse thread for hose of all kinds.

One other point, the last one, which has come to our attention, is the grounding of electrical equipment on house plumbing. Messrs. Minor, Sampson and Heffernan constitute the committee of this Association on this subject. They have submitted to us a letter which Mr. Minor sent to the National Fire Protection Association outlining the views of the American Water Works Association on this matter of grounding. In the first place, the letter states that water-works operators object to the use of their pipe systems as conductors of electric current; they do not object to protective grounding as such, providing the ground connection carries current only during the relatively short periods when these connections are fulfilling their protective purpose. In the second place, they object to the indiscriminate use of the piping system for electrical purposes. In the third place, they point out that no consideration is ordinarily given to the electrical continuity of the pipe system at the time the ground connections are installed. To sum up very briefly the objections are these: The water-

*Chairman of the Committee.

works' attitude is that satisfactory grounding practices can be established only through a comprehensive study of all of the factors involved and the adoption of a rigid supervisory policy regarding the installation and maintenance of ground connections.

Our committee in reviewing these objections agreed that it is true that grounding has been improperly done in many instances; but on the other hand, protective grounding of electrical equipment has accomplished such good results generally as regards personal safety to individuals who otherwise would be exposed to possible severe shocks that we believe that everything reasonable should be done to improve the practice of grounding so that it will not adversely affect the interests of the water works. We believe that with proper precautions, which can be taken without great effort, the water works should suffer no material damage to their property or injury to their employees.

We suggest, as the first step, that the NEW ENGLAND WATER WORKS ASSOCIATION collect through its members all of the data bearing on the weakness of present methods of grounding and that this material be carefully analyzed to determine if present methods can be improved; and if so, how? The data collected should be as broad as possible, bearing on the problem from all standpoints, such as the nature and extent of electrical damage that has occurred, as well as any record of shocks or injury to employees when meters have been removed or water connections have been broken. It would also be interesting to have data giving instances where the general results of the grounding have been satisfactory.

With such data at hand giving the amount and nature of trouble due to present methods of grounding, needed improvements will be revealed. Then we recommend that the NEW ENGLAND WATER WORKS ASSOCIATION have its representative attend conferences of the National Fire Protection Association to see what changes, if any, should be made in the National Electric Code in order to accomplish what is needed.

REPORT OF MASSACHUSETTS MEMBER OF THE COMMITTEE ON LEGISLATION.

BY GEORGE A. KING.*

The Legislative Committee is now constituted as a New England Committee instead of a Massachusetts Committee. It has a general chairman and one member from each of the New England states. Frank E. Barbour is the general chairman.

The Legislature of Massachusetts, by Section 2 of Chapter 396, Acts of 1928, repealed all acts which permitted cities and towns to incur liabilities without appropriation being made therefor. This act has altered the financial systems of many water departments, and they find that the department has lost control of moneys earned and held for future improvements.

The same Legislature created a Special Commission to investigate municipal expenditures and undertakings. This Special Commission reported to the Legislature in January, 1929, in House Bill 1 150, and recommended that after the first ten years from the installation of a water system "the rates should be so fixed that they will be adequate to meet all annually recurring charges, together with debt and interest charges. No portion of water revenue other than what would be a reasonable allowance for taxes, based upon what would be paid if the plant were privately owned, should be turned into the general treasury."

"The municipality should pay for water used for municipal purposes, the same as any other water taker; payment should also be made for hydrant rental, since for this service much larger mains and a greater supply of water must be provided than would otherwise be required for purely home consumption. The water taker should not either be unduly benefited or be penalized at the expense of the non-taker, or by a service for the benefit of all to which only a limited number contribute to its cost. Water revenue should be held entirely for water supply purposes, except as heretofore provided." The Commission also stated some reasons for its conclusions.

The report of the Commission was referred to the Committee on Municipal Finance of the Legislature.

At the call of our President a meeting of the Massachusetts members of the Association was held in the Auditorium of the State House on Wednesday, March 27, to obtain an expression of opinion from the water departments of the State upon the recommendations of the Commission. The following cities and towns sent representatives:

*Massachusetts Member of the Committee on Legislation.

Abington and Rockland	Holyoke	Somerset
Chicopee	Hudson	Somerville
Concord	Leominster	Taunton
Danvers and Middleton	Lexington	Ware
Dedham	Maynard	Wellesley
Duxbury	Milton	West Springfield
Everett	Needham	Winchester
Fall River	New Bedford	Winthrop
Falmouth	North Andover	Worcester
Fitchburg	Northampton	
Framingham	Scituate	

The following sent letters: Belmont, Cambridge, Gardner, Springfield.

In accordance with a vote of the conference the Special Commission was requested to submit with its report the following bill for enactment:

AN ACT REGULATING THE USE OF WATER DEPARTMENT REVENUE.

"Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

"Section 1. Chapter forty-four of the General Laws is hereby amended by adding the following new section;— *Section 2a.* All water department revenue shall be held and appropriated only for maintenance, operation and improvement of water works plants, for the retirement of water works bonds and for the payments of interest upon such bonds.

"Section 2. This act shall take effect upon its passage."

The Committee on Municipal Finance held a hearing upon the Commission's report on April 1, which was largely attended by water-works officials.

A letter was sent to the Senate Chairman of the Municipal Finance Committee, Senator Frank W. Osborn of Lynn, stating the arguments of the water departments upon the proposed legislation.

In the opinion of your Legislative Committee a basis for payment of hydrant rentals could not be studied and formulated in the time allowed for the drafting of a bill. Formulation of a bill to establish an equitable scheme of general application for determining valuations for tax making was even more difficult, required more study and consequently more time. Your Committee, therefore, asked that a special committee be appointed by the Legislature to consider these two points and report at the next annual session.

The Committee of the Legislature reported no recommendation upon the part of the Commission's report on water department finances. All the parts of the report of the Commission on which the Committee made no report were referred to the next annual session.

This action is the end of the matter unless someone has sufficient interest in it to revive it.

After discussion by Arthur D. Weston, S. S. Anthony, David E. Moulton, Stephen H. Taylor and John F. Sullivan it was moved, seconded and carried that the chair appoint a committee to act upon this matter.

PROGRESS REPORT OF THE COMMITTEE ON THE COLLECTION AND CORRELATION OF INFORMATION CONCERNING THE CORROSION OF IRON AND STEEL PIPES AND STANDPIPES.

BY CALEB M. SAVILLE.*

Your Committee on the Collection and Correlation of Information Concerning the Corrosion of Iron and Steel Pipes and Standpipes reports that the matter intrusted to it has received very little attention up to the present time, in view of the difficulty in obtaining concrete information, except so far as it can be abstracted from scattered literature.

Several very informal discussions have been had with individual members of the Committee, and it is expected that sufficient work will be accomplished within the next year to warrant at least a satisfactory progress report.

In the search for special information, a request for information was inserted as a display in a number of the JOURNAL of the Association, but the only response was from a member in the Philippine Islands, who sent a sample of steel from a pipe line, together with some description of conditions.

Offers of aid were also received from two of the small pipe manufacturers.

*Chairman of the Committee.

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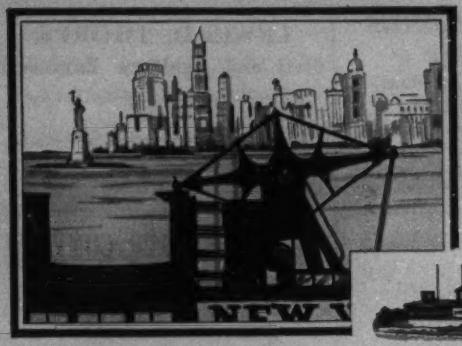

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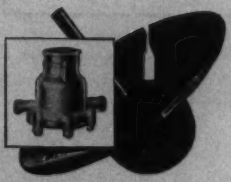

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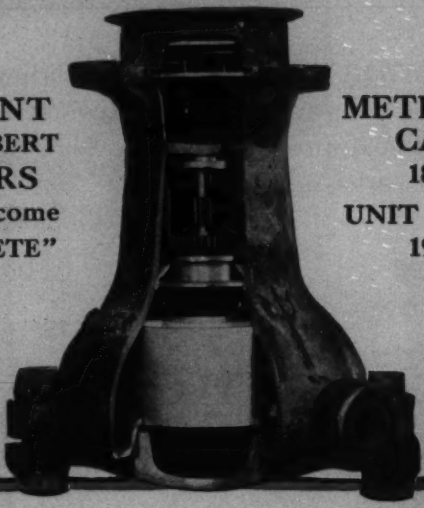


METER
CASING
1898
UNIT PARTS
1929

See this old Trident Casing (cut open and unretouched), still strong and sturdy after 31 years actual service. And see within it *new* Trident Unit parts — the up-to-date oil enclosed gear train, the heat proof and renewable rubber bushings in the register. There are thousands of "old" Tridents in service. New Interchangeable unit parts will make these meters *new* — good for years more of sustained accuracy in water revenue production.

NEPTUNE METER COMPANY
THOMSON METER CORPORATION
50 East 42nd Street, New York City
NEPTUNE METER CO., LTD.
Toronto, Ont.

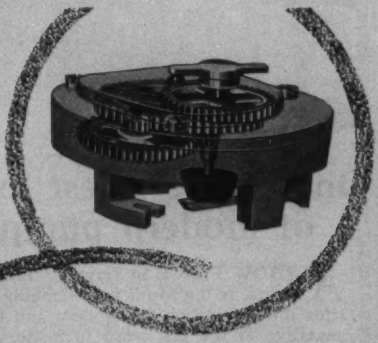
LAMBERT METERS ARE ALSO INTERCHANGEABLE

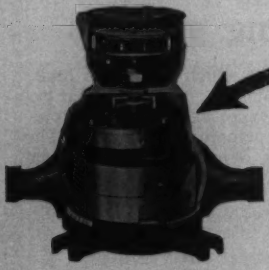
NO. 2

WATCH FOR NO. 3

INSIDE INFORMATION

Oil Enclosed Intermediate Train





THE oil enclosed intermediate train of the Arctic and Tropic meter is embodied in a bronze case entirely separate from the meter case. This construction not only protects the gears from corrosion and wear from sand or other foreign matters, but also secures equalized pressure on all sides of the intermediate train thereby lessening possibility of leakage of oil. Being mounted on the measuring chamber and not attached to the upper case, provides easy access for inspection either on the premises or in the meter shop.

Pittsburgh Equitable Meter Co.

Pittsburgh, Pa.

Branch Offices: Kansas City, Mo. Tulsa, Okla. Seattle, Wash. New York, N. Y. Chicago, Ill. Columbia, S. C. Dallas, Tex. Los Angeles, Cal. Salt Lake City, Utah

One of the finest examples of modern pumping stations

A SHOW PLACE in Dayton, Ohio, of which the city is justly proud, is the Municipal Pumping Station . . . a plant that excites the admiration of engineer and layman alike, for it is representative of the last word in modern pumping machinery. The station is equipped with the following Worthington Centrifugal Pumps, with a total capacity of 87,000,000 gallons every 24 hours.

No. of Units	Capacity of each in gals., 24 hrs.	Total head feet	Size and type of pump	Motor H. P. each unit
2	20,000,000	185	20″ O. S. M. single stage	850
1	20,000,000 or 10,800,000	185 (when operated in parallel) 350 (when operated in series)	two 14″ O. S.	850
2	6,000,000	350	10″ B. S. two stage	500
2	5,000,000	25	12″ O. S. single stage	30
1	5,000,000	32	12″ O. S. single stage	40

Quiet operation, and performance records that reveal a high efficiency with low power consumption and negligible maintenance cost . . . these, and a uniform reliability, reflect clearly the Worthington experience of 89 years in building sound pumping and power service machinery.

WORTHINGTON PUMP AND MACHINERY CORPORATION

Works: Harrison, N. J. Cincinnati, Ohio Buffalo, N. Y. Holyoke, Mass.

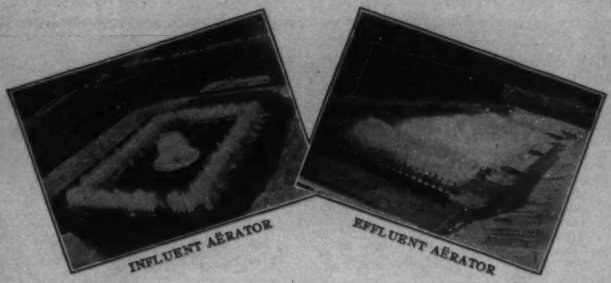
Executive Offices: 2 Park Avenue, New York, N. Y.

GENERAL OFFICES: HARRISON, N. J.

District Sales Offices:

Atlanta	Chicago	Dallas	El Paso	Los Angeles	Philadelphia	St. Paul	Seattle	
Boston	Cincinnati	Denver	Houston	New Orleans	Pittsburgh	Salt Lake City	Tulsa	
Buffalo	Cleveland	Detroit	Kansas City	New York	St. Louis	San Francisco	Washington	

Branch Offices or Representatives in Principal Cities of all Foreign Countries



Views at new Providence Water Works Scituate, R. I.

At Providence

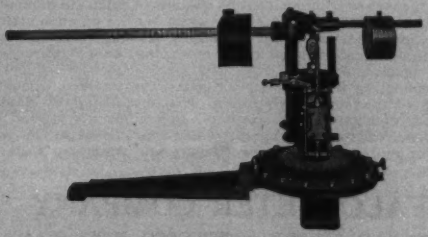
Hazen & Whipple Consulting Engineers, New York, N. Y.

the expenditure of twenty million of dollars and eight years of construction have resulted in providing the city of Providence with an abundant supply of pure clear water.

The Filter Effluent Aërators, a novel idea devised by the Consulting Engineers and developed by Builders Iron Foundry, is of particular interest. The head of water on the filter is used to produce secondary aëration. Constant flow through the filters is maintained by special Venturi-controlled mushroom valves which open gradually as the loss of head increases.

Special Venturi Meters measure the total water entering and leaving the plant; Builders Loss of Head and Rate of Flow Gages guide the operation of the filters.

Write for descriptive bulletins.

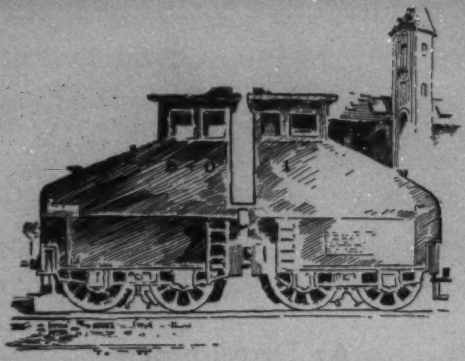


CONTROLLER PILOT VALVE UNIT

BUILDERS IRON FOUNDRY

"Builders of the Venturi for 36 Years"

Providence VENTURI **Rhode Island**



When ELECTRIC LOCOMOTIVES were new these METERS already had WON THEIR SPURS

'Way back in 1895, the first electric locomotive to be operated on a standard steam railroad, went into service in the Howard Street Tunnel — in Baltimore. With it, the B. & O. Railroad brought to the eyes of the world the commercial possibilities of electrified train service.

Two years before this, George Bassett, a water works construction and operating engineer, had built the first of the water meters to bear the familiar trade names "Niagara" and "American."

These meters (nearly a million of which are now in use) have saved thousands of municipalities millions of dollars in pumping costs. They have placed the payment for water service on an equality basis, have eliminated water waste, and by making municipal pumping stations self-sustaining or profit-producing, have lowered taxes in many communities.

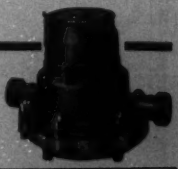
Among the hundreds saving money by universal metering are Duluth, Minnesota; Milwaukee, Wisconsin; Grand Rapids and Pontiac, Michigan — and scores of other cities and towns.

If you're interested in getting facts on water meters for your city, send for your copy of the new Niagara and American Water Meter Catalog — now.

BUFFALO METER COMPANY

2896 MAIN STREET BUFFALO, N. Y.

NIAGARA *and* AMERICAN
IRON CASE BRONZE CASE
Water Meters



The Chamber of Commerce of Worcester, Massachusetts, proudly throws the searchlight of publicity on the products of this great manufacturing community.

UNION Water Meter Company of Worcester, Mass. recently celebrated the sixtieth anniversary of its incorporation by producing the King F. P. (frost protected) Meter which experts agree overcomes all heretofore known weaknesses in design and construction. The new meter is also made with split case and interchangeable parts.

For 60 years most of the products of this company have been made in constantly improved form. Today the list of products includes Meters for Cold Water, Hot Water, Oil, Gasoline and other fluids; Union Fitts Chronometer Valves; Easy Turning Stops; Union Press for lining service pipe with cement; Union Pressure Regulators and Worcester Steam Fire Signals.

A summary of Worcester products is printed at the bottom of this advertisement. Complete information relative to any of them will be gladly supplied upon request.

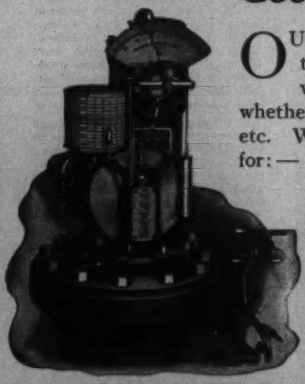
Worcester Chamber of Commerce
Worcester, Massachusetts

MADE IN WORCESTER, MASSACHUSETTS

Some of Worcester's 500 manufacturing plants are the world's largest producers in their lines. Among the thousands of products are the following leaders.

ABRASIVE PRODUCTS
AUTOMOBILE PARTS
BELTING
BLOWERS
BOILERS
BRUSHES
CARPETS AND RUGS
CASTINGS
CHAINS
CHAINS
CORSETS AND UNDERWEAR
CRANKSHAFTS
DRILLING MACHINES
DROP FORGINGS
DRYERS
ENVELOPES
FIREARMS
FIRE ALARM SIGNALS
FLOOR TILE
GRINDING MACHINES
GRINDING WHEELS
HARDWARE
LABELING MACHINERY
LATHES
LEATHER GOODS
LOOMS
LUNCH CARS
MACHINE TOOLS
MICROMETERS
MILLING MACHINES
MUSICAL INSTRUMENTS
OVERALLS
PAPER MAKING MACHINERY
PLANERS
PRESSED METAL
PULPSTONES
RADIOS
RAILWAY CARS
RAZORS
REFRACTORIES
ROLLING MILLS
ROTARY PRESS BLANKETS
SCREWS
SHOES
SEATS
SMALL TOOLS
SOLE LEATHER
SPRINGS
SPRINKLERS
STOPS AND VALVES
STOKERS
STRUCTURAL STEEL
TEXTILES
TEXTILE MACHINERY
TIRE FABRIC
VACUUM CLEANERS
VALENTINES
WALL PAPER
WATER METERS
WIRE
WIRE FABRICS
WIRE GOODS
WIRE MACHINERY
WOOD WORKING MACHINERY
WRENCHES

Is Your Pressure Low?
Are You Short on Pumping Capacity?
Do You Know Where Your Water Goes?



OUR Engineering Department will tell you how to determine your water distribution, how to find out whether or not new mains are required, etc. We can supply you with the means for: —

1. Checking up pump performance and determining slippage due to leaky plungers, defective valves, short stroking or other causes,
2. Measuring delivery of centrifugal pumps and figuring whether or not the station is up to efficiency,
3. Distributing proportionately the cost of water supplied to several districts,
4. Checking up the performance of filter beds,
5. Detecting waste or pipe leakage,
6. Recording daily amounts of sewage handled and planning future extensions, etc., etc.

THE SIMPLEX METER

VENTURI, PITOT TUBE OR ORIFICE TYPES

THE importance of exact measurements by means of a Simplex Meter cannot be over emphasized. Mr. Jeffries, Chairman of the West Chester, Pa. Water Works Committee, was able, by checking the performance of his pumping engine with a Simplex Meter, to discover that due to the imperfection and wear in the valves the slippage amounted to 300,000 gallons of water per day. This represented a daily loss of $30.00, or in other words a daily saving of $30.00, or $900.00 per month, when the valves were put in order. The Simplex Meter thus paid for itself in a month's time.

Frequent repeat orders from satisfied customers who formerly used other meters are the best evidence of merit of the Simplex Meter.

We have had many years' experience in solving water flow problems involving all sorts of conditions, and we are at all times prepared to submit general layouts involving cost and capacity, and to make explicit and complete recommendations. Write for Bulletin N26.

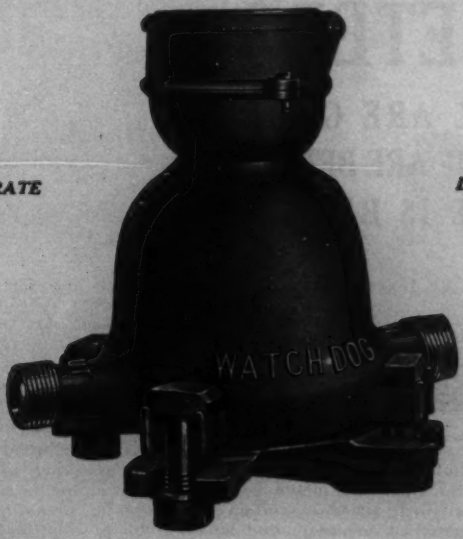
SIMPLEX VALVE AND METER COMPANY

Manufacturers of Meters for Water, Sewage, and Other Liquids, Rate Controllers, Automatic Air Valves, Regulating Valves, and Hydraulic Apparatus of Special Design.

6757 UPLAND STREET PHILADELPHIA, PA.

"WATCH DOG" WATER METERS

ACCURATE *DURABLE*



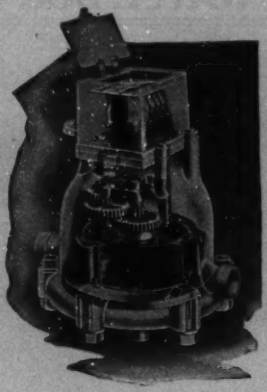
DISC, CURRENT AND COMPOUND TYPES

Inquiries Solicited

GAMON METER COMPANY

NEWARK NEW JERSEY

WATER METERS



ALL ARE GOOD
SOME ARE BETTER
ONE IS BEST —

At least we think so, and that one is - - -

The EMPIRE
OSCILLATING PISTON METER

To say that anything is the "best" is a pretty broad statement, but there seems to be good reason for speaking that way about the EMPIRE meter, because it has been on the market for nearly forty-six years, and no other meter has ever surpassed it in sustained accuracy; and no other meter can show such records of long service, often with no repairs at all, and in all cases with unequaled economy of maintenance.

If accuracy, lasting qualities, and low upkeep can make a meter the "best," we have used the right word to describe the EMPIRE.

An EMPIRE circular will fit your files, and give you useful information about this useful meter. Send postal for a copy.

NATIONAL METER COMPANY

299 Broadway, New York

New England Branch, 287 Atlantic Ave., Boston, Mass.

Chicago Cincinnati San Antonio Atlanta
San Francisco Los Angeles Toronto, Ont.

DO Climatic Conditions Affect Your METER SERVICE?

IF so . . . you may have a Badger Meter to meet your exacting conditions.

For the frigid north . . . there is the Model "A" . . . a sensitive disc meter with oil enclosed gear train and breakable bottom plate which is easily replaced in the event of freezing. Its companion, the Split Case with oil enclosed gear train effectively serves the warm southern sections.

May we send you detailed Bulletin?

BADGER METER MANUFACTURING CO.

MILWAUKEE WISCONSIN

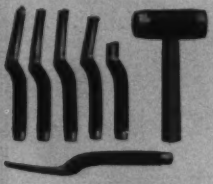
Branch Offices:

NEW YORK CITY LOS ANGELES, CAL. CINCINNATI, OHIO
KANSAS CITY, MO. CHICAGO, ILL. SEATTLE, WASH.

BADGER Water METERS

It pays to buy good tools

Workmen equipped with ***good*** tools — the kind they would buy themselves — turn out the best work. It ***pays*** to buy good tools.



Mueller G-10680
Water or gas main calking set for mains 12 in. or smaller. Regularly furnished in a leather carrying case as illustrated. Space is provided in the case for a suit of overalls.

Mueller G-10681
Lead wool calking set. Includes one Yarning Iron, five Calking Irons (made especially for calking lead wool), and a Calking Hammer.

MUELLER CALKING TOOLS

Mueller Calking Tools are the kind of tools men like to use. They're made for the work they do so well and they help to turn out calking jobs that keep mains tight, reduce maintenance expense and maintain uninterrupted service.

Mueller Calking Tools are ***good*** tools—the best that can be made. Hand forged, oil tempered, finely polished and rigidly tested—they live up to Mueller's 72-year reputation for quality. They are made in a variety of styles and can be purchased in sets with carrying cases when so desired.

When you buy calking tools insist on the Mueller name — ***it pays.***

MUELLER CO. ***Established 1857*** **Decatur, Illinois**

Branches: New York, Dallas, San Francisco, Los Angeles
Canadian Factory: MUELLER, Limited, Sarnia

MUELLER

ATTENTION
WATER WORKS
OF NEW ENGLAND

A few reasons why we solicit your inquiries on Water-Works Pumping Equipment:

First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

Third. — We relieve the purchaser of every detail and turn the complete unit over to him under actual operation and with guarantee.

Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.

Remodeled Pumping Station at Bridgewater, Mass., completely installed by F. A. Mazzur Co., Inc. Barbour & Dixon, Eng'r's.

F. A. Mazzur Co., Inc.

141 MILK STREET, BOSTON

A TYPICAL TURBO CENTRIFUGAL SET

There are many existing steam pumping plants with good boilers, where increased capacity or improved efficiency can be secured by installing a condensing unit such as illustrated above. Unless current can be purchased at very low price, this type will pump water for less cost. Even if boilers are replaced, the comparison is frequently favorable to the steam unit, and the service is free from interruption and always reliable.

We are prepared to bid on complete plants under one responsibility.

Many Successful Installations

MORRIS PUMPS MURRAY TURBINES

STARKWEATHER & BROADHURST, INC.
ENGINEERS AND CONTRACTORS
BOSTON
79 MILK STREET HANcock 4530

HAYES PUMP AND MACHINERY CO.

94 PEARL ST., BOSTON, MASS.

Pumping Plant Contractors

CENTRIFUGAL, POWER, STEAM PUMPS

STEAM TURBINES
WATER WHEELS

ELECTRIC MOTORS
OIL ENGINES

UNIVERSAL CAST IRON PIPE

The Central Foundry Company

Graybar Building, 420 Lexington Ave.
NEW YORK CITY

CHICAGO	BIRMINGHAM	DALLAS	SAN FRANCISCO
332 S. Michigan Ave.	Comer Bldg.	Praetorian Bldg.	Rialto Bldg.

POWER EQUIPMENT COMPANY

250 STUART STREET
BOSTON

New England Distributors for
Dayton Dowd centrifugal pumping units.

Among recent Municipal installations in New England are

Town of Walpole, Mass.
City of Chicopee, Mass.
City of Fairhaven, Mass.

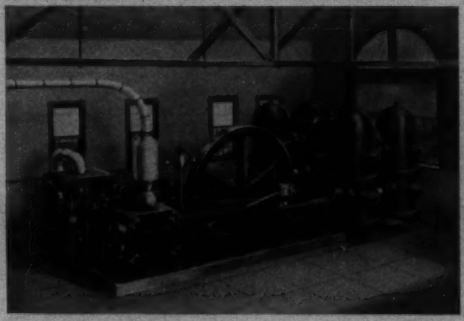
We shall be glad to co-operate with interested Purchasers.

MURRAY IRON WORKS CO.

(INCORPORATED 1876)

BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines

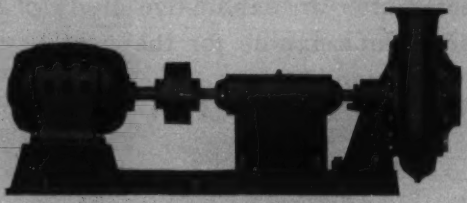


Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

STARKWEATHER & BROADHURST, INC.,
79 MILK STREET, BOSTON

will be glad to show you the superior design and excellent workmanship of the new 3 M. G. D. Murray Pump in the Arlington Pumping Station of the Metropolitan District Commission. Exceptional operating results are being obtained as shown by the official duty test which exceeded the guaranty by a substantial amount.

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS



Fairbanks-Morse Horizontal Trash Pump direct-connected to Fairbanks-Morse Ball-Bearing Motor

Now a great advance in sewage pumping

For the first time a pump has been designed that will handle fluids containing the fibrous and stringy matter found in sewage — without clogging, without preliminary screening, and without the excessive power consumption that characterizes the less satisfactory open impeller type of pump.

The secret of this pump's success lies in the design of the simple two-blade impeller. The blades of the impeller have well-rounded entering ends and are well filleted with the shrouds or sides. Thus a rag or other trash does not find sharp projections on which to catch and cause clogging. Since the impeller is the enclosed type, foreign matter, in passing through, does not come into contact with stationary side plates, but is promptly discharged through one of the large ports into the pump case. In this way power is conserved and efficiency increased.

This pump was designed by Mr. A. B. Wood who has been serving the city of New Orleans and other municipalities in the capacity of consulting engineer. It was originated by Mr. Wood to cope with the very unusual sewage problems found in New Orleans and met with immediate success.

Fairbanks-Morse Trash Pumps are made in two types, horizontal and vertical. They are ruggedly built to cope with severe service and at the same time they possess such refinements as ball bearings, smoothed fluid passages, and other marks of quality construction.

Ask for bulletins giving complete details.

FAIRBANKS, MORSE & CO., Chicago

28 branches in principal cities at your service.

FAIRBANKS-MORSE

PUMPS · DIESEL ENGINES · MOTORS

DELAVAL EQUIPMENT

was selected after an exhaustive study of the conditions and requirements for the new waterworks plant at Old Town, Maine.

A carload of DE LAVAL motor and gasoline engine driven pumps before shipment to Old Town, Maine

DeLaval's exceptionally high efficiency enables water to be pumped at minimum cost. All parts are made to limit gauges on an interchangeable basis. Each unit is fully guaranteed and tested under operating conditions before leaving the factory.

TURBINE EQUIPMENT CO. OF NEW ENGLAND

Engineers and Contractors

80 Federal Street, Boston **Telephone LIBerty 5993**

New England Representative for

DELAVAL STEAM TURBINE COMPANY

Trenton, N. J.

THE NEW

W & T Dry Chemical Feeder

TYPE 'O'

Rugged · Accurate Economical

THIS new W & T Dry Chemical Feeder is designed to meet all low feeding requirements with finely powdered or coarse granular chemicals. The feeding range is from 1/10 lb. to 80 lbs. per hour, depending on chemical used. Adjustment by a hand wheel is simple and accurate.

Among the many distinctive features of this new dry feeder are:

- Self-agitating and non-arching hopper
- Non-clogging throat
- Direct drive mechanism
- No pulleys or belts
- Low power consumption
- May be operated from a lamp socket—no special and expensive wiring necessary
- Clean and dust-proof
- Perfect mechanical construction of all moving parts
- Adaptable for overhead feed—direct or solution discharge
- Can be set up anywhere; easily moved
- Neat in appearance—all exposed mechanical parts cadmium plated

"The only safe water is a sterlized water"

WALLACE & TIERNAN

COMPANY, INCORPORATED

Manufacturers of Chlorine Control Apparatus

NEWARK · NEW JERSEY

NEW YORK CHICAGO KNOXVILLE SAN FRANCISCO MINNEAPOLIS PITTSBURGH DALLAS
KANSAS CITY LOS ANGELES SEATTLE ST. LOUIS BUFFALO INDIANAPOLIS DETROIT
BOSTON JACKSONVILLE CHATTANOOGA CHARLOTTE OKLAHOMA CITY PHILADELPHIA
SPOKANE WALLACE & TIERNAN, LTD., TORONTO, CANADA OGDEN
WALLACE & TIERNAN, LTD., LONDON, ENGLAND

B-40

CMC

FILTER ALUM

FOR NEW ENGLAND WATER WORKS

MERRIMAC CHEMICAL COMPANY

148 STATE ST. BOSTON

MANUFACTURERS OF FILTER ALUM
SINCE 1886

O'BRIEN HYDRANTS
Mean No Flooded Streets

THE famous O'Brien Hydrant may be flattened to the sidewalk in a collision with an automobile truck. No practical construction could withstand such impacts. But even under such severe conditions, it will still hold the water.

SMITH WATER WORKS SPECIALTIES & SUPPLIES A.P.S. 1928

THE A.P. SMITH MFG. CO. *East Orange, N.J.*

CLARK
METER YOKES

Because of its circular construction, the Clark Meter Yoke offers the advantages of great strength combined with light weight.

[illegible]

CLARK

H. W. CLARK COMPANY

Manufacturers of Water Works Necessities

MATTOON, ILL., U. S. A.

PRECALKED JOINT PIPE

CAST IRON PIPE

Bell and Spigot—Sand Cast—Modern Weights

Sizes: 1¼ through 12 inches. Lengths to 16 feet

Boston stocks. Furnished with or without Precalked Joints

McWane Cast Iron Pipe Company

Eastern Office: 123 South Broad Street Philadelphia

Sales Representatives: FRED A. HOUDLETTE & SON 40 Central Street, Boston Eastern Mass., Me., N. H.

General Offices: BIRMINGHAM, ALA.
Foundries: BIRMINGHAM, ALA., PROVO, UTAH

Main's Hotcoating for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

Also

Main's Coverall Salt Air Paint, for the outside of standpipes and water tanks, guaranteed for four years.

M. B. MAIN **Box 189, Somers Point, N. J.**

WARE

RED BRASS NIPPLES

Standard and Extra Heavy
85% Copper Content Guaranteed

Diameters from 3/8″ to 4″ inclusive.
In stock, ready for 24-hour shipment.

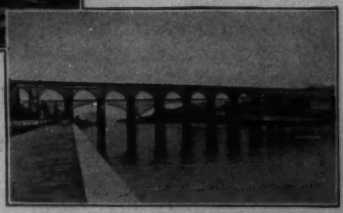
Order through your Jobber, or write us direct for name of nearest distributor.

WARE COUPLING & NIPPLE CO.
WARE, MASS., U. S. A.

Four Generations Have Passed

since the Croton Aqueduct was built . . . .

Yet the wrought iron pipe is still good for generations more!



Away back in the 60's, before the Civil War, a 90-inch wrought iron pipe was installed on High Bridge to carry water from the Croton Aqueduct, across the Harlem River, to New York.

In 1925, when plans for altering High Bridge were being discussed, the question arose whether the big water main was in a condition to be worth saving.

"Good for twenty years," reported the engineers after careful inspection. "Capable of being made to last another sixty years if a protective coating is applied to the inside."

Not a unique but a noteworthy example of the sterling qualities of genuine wrought iron pipe, in water works economy.

Genuine wrought iron is the material from which Byers Pipe has always been made. All the virtues for which Byers Pipe has been known to four generations are built into every length turned out by the Byers mills. The bright Spiral Stripe, which is the Byers mark, is an assurance of lasting service.

A. M. BYERS COMPANY
Established 1864
PITTSBURGH, PA.
Distributors in all Jobbing Centers

the *Spiral Stripe* protects you against mistakes and substitution

BYERS PIPE

GENUINE WROUGHT IRON

PIERCE-PERRY CO.

SUCCESSORS TO
GEORGE E. GILCHRIST CO.

JOBBERS OF
Heating and Plumbing Supplies
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Hoffman Valves and Controlled Heat Equipment

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CAST IRON BELL AND SPIGOT
WATER PIPE AND FITTINGS
FLANGED PIPE in full and short lengths
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Manufacturers of and Dealers in
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For Standard and High Pressure Service

Mathews Hydrants are simple in construction; hence durable, easily repaired, and maintained at low cost.

A real Frost Case makes Mathews Hydrants completely frost proof, and with an easily installed

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makes the Mathews readily adaptable to new grades and conditions.

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"Sand-Spun" centrifugally cast pipe
Cast in refractory molds
No chill—Standard bell and headed spigot

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WATER supply and fire protection equipment *must* be thoroughly dependable. Only apparatus of the highest possible grade, meeting the most rigid requirements, can be used.

The wide use of Kennedy Valves and Fire Hydrants by villages, towns and cities throughout the country is therefore the strongest possible proof of their general acceptance as being reliable and efficient. Both large and small municipalities by the score are safely depending on Kennedy products for the control of water supply and fire protection systems.

The big Kennedy line of thousands of different types and sizes of valves, pipe fittings and fire hydrants includes every valve size and method of control for large pipe line operation. Send for the Kennedy Catalog to learn the distinctive features and advantages of Kennedy products.

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VALVES-PIPE FITTINGS-FIRE HYDRANTS

Automatic Pressure Control Valves
Feed Water Filters
Portable Fire Hydrant Heads
Hydraulic Engines
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ESTABLISHED 1879

Health and Protection First

Water delivered through dirty pipes may be a MENACE.

Incrusted water pipes mean inefficiency and loss of Fire Protection.

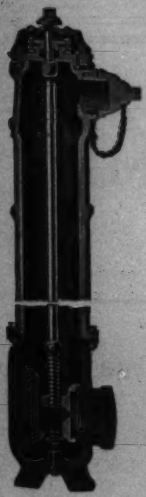
We Guarantee the Results of Our Method of Cleaning.

WRITE US.

National Water Main Cleaning Co.

50 Church Street New York City

A Classified Directory
of Advertisements is arranged for your convenience in the back of this Journal.



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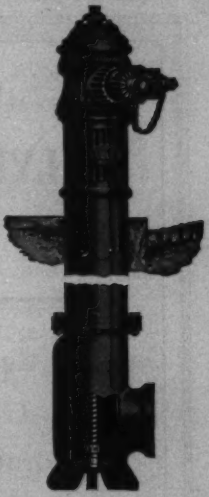
VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



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YARD, WASH, AND FLUSH HYDRANTS.

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The Knuckle Joint Principle in Genuine "Rensselaer" Improved "Corey" Fire Hydrants—Means Ease of Operation

BECAUSE this principle gives great power to open or close the gate just when it is needed, and speed in movement when power is unnecessary.

The first turn of the spindle, when the gate is open, moves the valve nearly two inches, after which the speed decreases and power throughout the knuckle joint increases, until at the time of closing the valve moves scarcely one-sixteenth of an inch at each turn of the spindle, eliminating danger from water hammer when closing hydrant.

The gate is closed very tight with slight application of power to the wrench by the operator. The drip valve in the Corey Fire Hydrant prevents freezing. No accident or damage to property can occur with this hydrant by flooding the streets where runaway teams or other accident breaks off or otherwise injures the hydrant standpipe, if hydrant was properly closed at time of accident.

It will be readily seen that the hydrant gate is held in position when shut by the four arms forming braces between the back of the hydrant and the seat, consequently the hydrant barrel can be broken completely off above the ground, but the valves remain tight.

Write for copy of our Hydrant Book No. 9.

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New England Sales Manager, Lock Box 2, Northboro, Mass.

RENSSELAER VALVE COMPANY

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Manufacturers of

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Type of Eddy Hydrant Popularly Used

More Than Sixty Years of Experience Goes Into All

EDDY

Hydrants and Valves

BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

The Eddy Valve, Too

Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.

Other Eddy Products

The Eddy line of water-works products also includes horisontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

WRITE FOR CATALOGUE

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WATERFORD, N. Y., U. S. A.

EMAUS PIPE FOUNDRY,
DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND...

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

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CALDWELL "LEAKFINDR"

Listening for leak at hydrant

Locating leak in the ground

Pronounced by Leading Water Works Superintendents the Best Instrument for the purpose on the market.

Manufactured and Sold by

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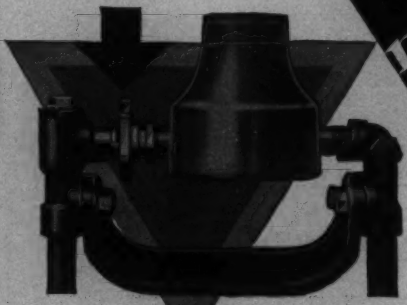
No. 1 CALDWELL CURB BOX

THE FORD EXPANSION CONNECTION

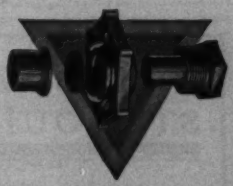


Save time and money!

...*with the* FORD EXPANSION CONNECTION

THE Ford Expansion Connection furnished with the Ford Yoke is *unique, outstanding!* There is nothing else like it in principle or convenience... *internal expansion outward* against fixed ports and gaskets. It makes possible the removal or placing of a meter without the use of a wrench.

Just a few turns of the large *handwheel* makes or unmakes a water tight joint. All moving parts are of bronze and are removed with the meter which prevents bridging through to steal water. Tens of thousands of Ford Yokes in use for many years prove their dependability.



Connection is screwed on meter spud with a wrench. The meter with Connection attached is dropped in the saddles of the yoke where rubber gaskets are held in recessed ports. Turning the handwheel expands the connection, making a perfect compression joint.

Send for Bulletin

WATER METER SETTINGS & TESTING EQUIPMENT

THE FORD METER BOX CO.

WABASH, INDIANA

Corrosion of Iron and Steel Water Pipes

Information on this subject is desired by the Committee recently appointed by the Association "to Collect and Correlate Information Concerning the Corrosion of Iron and Steel Pipes and Standpipes." Members are urged to send data relating to the characteristics of the metal, the soil, the water and the protective coatings and to the history and condition of such supply mains (not service pipes) to the undersigned for the use of the Committee.

CALEB MILLS SAVILLE, *Chairman.*
1026 Main Street, Hartford, Conn.

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JOHN FOX & CO.

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WATER & GAS PIPES

FLANGE PIPE

Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

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ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments
use
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for their service connections

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PUMP UNIT

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Bell and Spigot Flanged Pipe
Special Castings
Flexible Joint Pipe Cylinders

Water Gas Sewers Culverts

Works, Phillipsburg, N. J.

LARGE STOCK ENABLES US TO MAKE QUICK SHIPMENTS

LEADITE

Deflection 6'3", pressure over 300 lbs.,— yet LEADITE joints "held tight."

Seven lengths of 6" c. i. bell and spigot pipe (length, 84'; capped and plugged; total, 8 joints) were jointed with LEADITE — average, 2¼ pounds LEADITE used per joint. These 7 lengths were supported on blocking, and the line was levelled. The intermediate blocking then was knocked out — allowing line to drop — air pressure at this stage being 95 lbs. per square inch and the deflection 27". Line was then subjected to water pressure.

To make a long story short, a final deflection under water pressure of 6'3" was reached (see actual test photo above). At this stage the water pressure was over 300 lbs. per square inch. The effective depth of LEADITE in all joints in contact with the iron was only 1" from face of bell (customary practice is 2½" depth of joint).

These tests conclusively proved the great flexibility of LEADITE joints and bell and spigot pipe — and also the wonderful holding qualities of LEADITE.

The pioneer self-caulking material for c. i. pipe.

Tested and used for over 30 years.

"Saves at least 75%"

THE LEADITE COMPANY

Land Title Bldg. Philadelphia, Pa.

No Caulking

National-Boston Lead Co.

800 Albany St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

PIG LEAD

Joints that are Stress and Vibration Proof

Unusual situations often met in laying bell and spigot pipe — lines over bridges or railroad crossings — lines to be lowered to grade — are successfully met when the joints are made with Hydro-Tite.

Easy to Prepare

The 8-in. line pictured above is slung across a pond with cables — a span of more than fifty feet.

Every test shows that Hydro-Tite joints will remain perfectly tight when subjected to severe vibration or deflection. If you have never used Hydro-Tite let us tell you more about it. Requires no caulking — 19 years of proven dependability — a real 75% saving and an ever-increasing list of satisfied users.

Easy to Pour

Write for literature and further information.

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7 So. Dearborn St.

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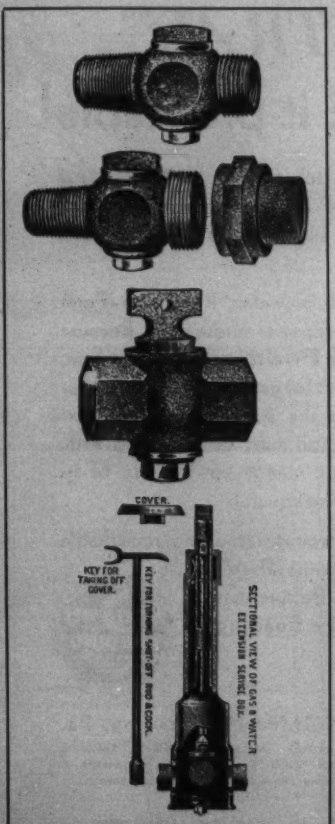
The MODERN JOINT MATERIAL

"The Goods That Please"



Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

Let us send at our risk, on 30 days' trial, a

Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

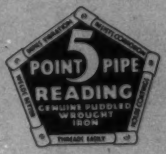
Established 1869

It's the "EXTRAS" that make it profitable!

It is the ***extra*** factor of safety—the ***extra*** ability of Reading 5-Point Pipe to meet the hardest conditions—that makes it so profitable in water works service.

In contact with earth or water, Reading 5-Point Pipe soon shows its superior endurance. Because this pipe is Genuine ***Puddled*** Wrought Iron, corrosion is barred out for generation after generation. And wherever the strains set up by expansion and contraction must be reckoned with, Reading 5-Point Pipe stands up because of its tough, fibrous rope-like structure.

Ages of use have demonstrated the remarkable lasting power of Genuine ***Puddled*** Wrought Iron. Be sure that you get it—specify Reading 5-Point Pipe.



READING IRON COMPANY, Reading, Pa.

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Chicago Houston Pittsburgh Tulsa Seattle Boston Cincinnati
Los Angeles Cleveland San Francisco Philadelphia New Orleans Kansas City

GENUINE PUDDLED WROUGHT IRON
READING PIPE
DIAMETERS RANGING FROM ¼ TO 20 INCHES

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Altitude Valves

We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves":
1st —Automatically, by water.
2nd—By Electricity, if desired.
3rd —By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. No valves or fixtures inside or outside.

Sizes to 24 in.

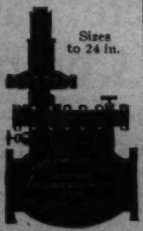
Remember!

"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

"Made with stop starter attachment for centrifugal pumps"

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required — No attention necessary.
5. Positively no hammering or sticking.



Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle — Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.

Angle or Globe

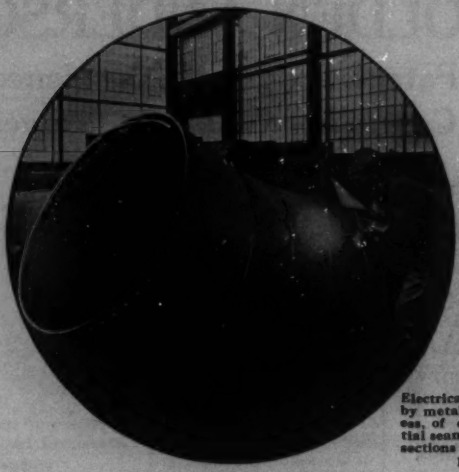
Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Double Cushioned Check Valve

Sizes to 24 in. Angle or Globe

Automatically prevents reverse flow of pressure. Perfectly cushioned to prevent shock or hammer. Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping. Arranged so that quick or slow operating may be obtained.

Golden-Anderson Valve Specialty Co., 1325 Fulton Bldg., Pittsburgh, Pa.



Electrically welding, by metallic arc process, of circumferential seams on special sections of 42" welded pipe.

Biggs' Complete Facilities Are At Your Command

The most modern and thorough methods mark all of Biggs' fabrication and construction. Biggs Welded or Riveted Steel Pipe, with its high elastic limit and ductility, leaves no unknown factors to the imagination. Biggs places at your command a complete construction service, modern field equipment, and specialized facilities backed by forty-two years' experience.

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BIGGS Steel Pipe *Riveted and Welded*

THE BIGGS BOILER WORKS CO. AKRON, OHIO

In 9 cases out of 10 *Reduced Water Flow is due to* Rusted Plumbing in the Home

RELIABLE figures show that in nine cases out of ten complaints by property owners of reduced water flow are the result of rust-clogged pipes *in the home—not* of poor water pressure, or inadequate supply, or any other fault attributable to the city water service. Yet municipalities are put to considerable expense for the maintenance of Service Departments which are constantly investigating such complaints by residents.

Where Copper or Brass is used for both plumbing and service pipe perfect water service is assured. In their contact with home owners city inspectors should urge the use of Copper or Brass pipe. Recommend them to plumbing contractors and builders. Advise their use in all public and government buildings. And *use them yourself*—for all service pipe.

Although it costs a trifle more in the beginning, pipe of Copper or Brass is *always* an economy in the long run. Its use eliminates rust and the clogging of pipe that inevitably results where rust occurs. Once installed, Copper or Brass serves without repair or replacement for *generations*.

We will be glad to cooperate with you to the fullest extent in any efforts you care to make toward furthering the use of Copper or Brass pipe. Write for full information.

COPPER & BRASS
RESEARCH ASSOCIATION
25 Broadway, New York

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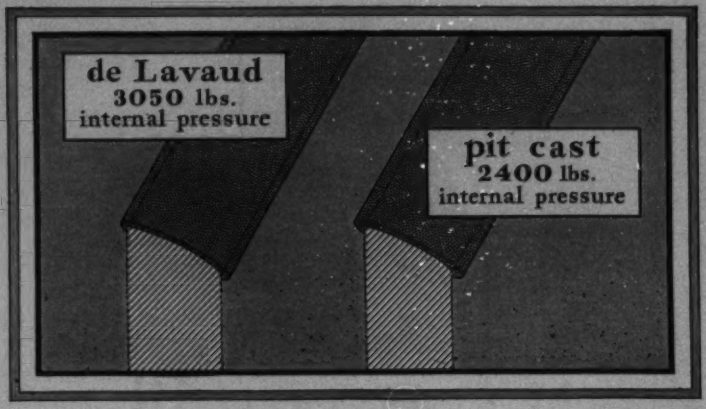

deLavaud...the pipe of greater carrying capacity and greater strength

THE diagram shown above graphically tells the story of deLavaud's superiority over pit cast pipe. These two sections have precisely the same outside diameter. Note, however, that the deLavaud pipe has a greater inside diameter and therefore a greater carrying capacity. Yet, *exhaustive tests have proved that deLavaud pipe is more than 25% stronger* than any pit cast iron pipe.

In hydraulic bursting tests conducted by a well-known authority deLavaud pipe proved its superior strength by resisting an internal pressure of more than 3000 lbs. per squ. in. This was far greater pressure than pit cast pipe withstood.

The remarkable strength of deLavaud pipe results from the dense, close grained structure of the metal, and from its freedom from slag and blow holes. deLavaud pipe is made by pouring molten iron into a rapidly revolving cylindrical mould. Centrifugal force holds metal against sides of mould, *driving out impurities with a force 40 times greater than gravity.*

Also, the action of water-cooled deLavaud mould and the subsequent annealing further improve the physical properties and the microstructure of the metal. Let us send you the deLavaud handbook and the complete facts and figures about deLavaud pipe.

Cast iron pipe made by this Company bears the "Q-check" trademark of The Cast Iron Pipe Research Association.

United States Pipe and Foundry Co., Burlington, New Jersey

Sales Offices: New York, Philadelphia, Pittsburgh, Cleveland, Buffalo, Chicago, Dallas, Birmingham, Kansas City, Minneapolis, Seattle, San Francisco, Los Angeles

0.01 PART PER MILLION CHLORINATION ACCURACY

with this new LaMotte Chlorine Colorimeter Set!

YOU CAN now eliminate all guesswork in the treatment of drinking water with this accurate LaMotte outfit. It actually detects differences of 0.01 part chlorine per million parts water, regardless of impurities! And yet the method entails nothing more than a simple comparison between special sealed Nessler Tube Standards and the prepared sample. The LaMotte Chlorine Colorimeter Set insures simple operation, accurate results — and economy! Order a set today, or write for complete information. Set, Complete, F. O. B. Baltimore, $25.00.

WATER ANALYSIS, whether for sterilization, purification or softening, requires special apparatus, standards and solutions. The chlorine colorimeter described above is only one of the many practical sets scientifically developed in our Research Laboratories. Colorimetric testing apparatus is now available for every type of water, sewage, and industrial water analysis. For use in such processes, a complete series of standards and solutions have been prepared in accordance with "Standard Methods of Water Analysis," published by The American Public Health Association. These are applicable not only to special LaMotte testing sets, but to all standard methods now in use. Write today for complete information.

The 5th Edition of our illustrated book, The A B C of Hydrogen Ion Control contains many practical suggestions on water works applications. A copy will be sent you upon request.

LaMotte Chemical Products Company

428 Light Street . . . . . Baltimore, Md.

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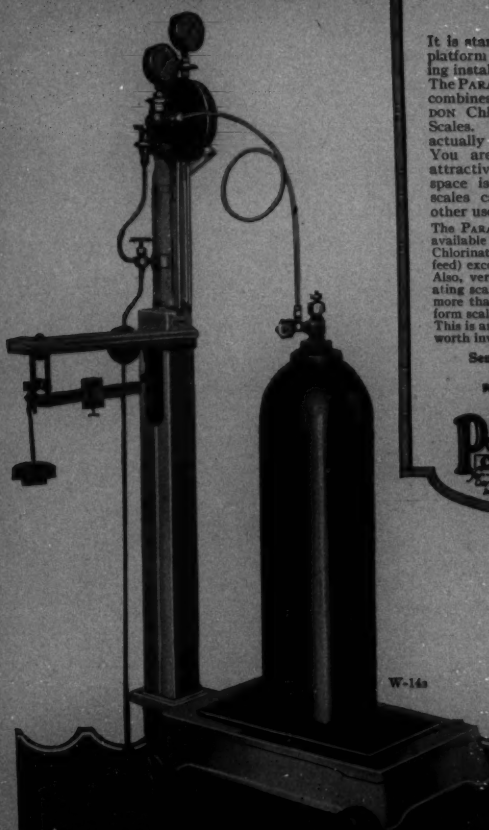

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